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COMMITTEE ON THE DEVELOPMENT AND UTILIZATION OF NEW AND RENEWABLE SOURCES OF ENERGY
Intergovernmental Expert Group on Assessment and Review of the Nairobi Programme of Action for the Development and Utilization of New and Renewable Sources of Energy
26-30 August 1991
Item 1 of the provisional agenda

ADOPTION OF THE AGENDA AND ELECTION OF OFFICERS

Provisional agenda

1. Adoption of the agenda and election of officers.

2. World energy situation and prospects:

   (a) Situation at the time of the United Nations Conference on New and Renewable Sources of Energy;

   (b) Trends since the Conference;

   (c) Implications for new and renewable sources of energy.

3. Progress achieved in the implementation of the Nairobi Programme of Action.

4. Factors bearing on the implementation of the Nairobi Programme of Action:

   (a) Institutional considerations and coordination;

   (b) Policy;

   (c) Financial considerations.

5. Other factors:

   (a) Environmental and socio-economic issues;

   (b) Commercialization;

   (c) Marketing;

   (d) Manufacturing capabilities and possibilities;

   (e) Rural energy supplies.

6. Future action to promote the implementation of the Nairobi Programme of Action:

   (a) Specific and overall new and renewable sources of energy;

   (b) Areas of priority action as identified in the Nairobi Programme of Action;

   (c) Financing new and renewable sources of energy;

   (d) Institutional arrangements;

   (e) Policy orientations;

   (f) Other considerations.

7. Adoption of the report of the Expert Group.

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COMMITTEE ON THE DEVELOPMENT AND
UTILIZATION OF NEW AND RENEWABLE
SOURCES OF ENERGY
Intergovernmental Expert Group on
Assessment and Review of the Nairobi
Programme of Action for the
Development and Utilization of New
and Renewable Sources of Energy
26-30 August 1991
Items 2, 3 and 4 of the provisional agenda*

WORLD ENERGY SITUATION AND PROSPECTS

PROGRESS ACHIEVED IN THE IMPLEMENTATION OF THE NAIROBI PROGRAMME OF ACTION

FACTORS BEARING ON THE IMPLEMENTATION OF THE NAIROBI PROGRAMME OF ACTION

Assessment and review of the implementation of the Nairobi Programme of Action for the Development and Utilization of New and Renewable Sources of Energy

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INTRODUCTION

1. The Committee on the Development and Utilization of New and Renewable Sources of Energy, at its fifth session (26 March to 4 April 1990) decided, inter alia, to inscribe the item "Commemoration of the tenth anniversary of the adoption of the Nairobi Programme of Action for the Development and Utilization of New and Renewable Sources of Energy" on the agenda of its sixth session, to be held in 1992. The Committee decided to convene an intergovernmental expert group meeting in 1991 to assess and review the process of implementation of the Nairobi Programme of Action and to make concrete recommendations on all aspects of its implementation, including institutional ones, with a view to assisting the Committee at its sixth session in the consideration of the item, and to take measures designed to speed up the implementation of the concerted measures envisaged in the Programme. 1/ The decision of the Committee was endorsed by the General Assembly in its resolution 45/208 of 21 December 1990.

2. The present report was prepared in response to the Committee's decision. It gives an overview of the progress achieved at the national level and through bilateral and multilateral cooperation in the implementation of the Nairobi Programme of Action during the past decade and offers an analysis of factors bearing on the implementation. It is based on information received from countries and entities within the United Nations system and on studies by the Secretariat, with the assistance of consultants in specific subject areas.

I. NAIROBI PROGRAMME OF ACTION

A. Objectives

3. The fundamental objective of the Nairobi Programme of Action for the Development and Utilization of New and Renewable Sources of Energy which was adopted at the United Nations Conference on New and Renewable Sources of Energy (Kenya, 10-21 August 1981) and by the General Assembly in resolution 36/193 of 18 February 1982, 2/ is to promote concerted action in the context of energy transition and the development and utilization of new and renewable sources of energy, with a view to helping meet future overall energy requirements, especially those of developing countries. The Programme of Action is directed towards the achievement of the following goals:

(a) To strengthen international cooperation for the promotion and intensification of research into and development of technologies related to new and renewable sources of energy and to facilitate the transfer and adaptation of technology from developed to developing countries, in particular, and the exchange of technology among developing countries, in order to strengthen indigenous scientific and technological capacities, including the capacity for the production of capital goods in developing countries;

(b) To stimulate the mobilization of additional and adequate financial resources from developed countries, international financial institutions and other international organizations and the private sector, as appropriate, to the developing countries for the development of new and renewable sources of energy through programmes and projects at the national, subregional, regional and international levels. Other countries in a position to contribute should also continue to do so;

(c) To provide, through international cooperative efforts, for the exchange of information and worker training, particularly in the developing countries, and to promote their ability to undertake energy resource evaluations and energy planning in order to accelerate the introduction of new and renewable sources of energy in their energy balances;

(d) To promote and provide support for the attainment of the national objectives and priorities established by developing countries in the field of new and renewable sources of energy related to the strengthening of their national capabilities and institutional infrastructures for the effective incorporation of new and renewable sources of energy into national policy and planning processes and the drawing up and the implementation of programmes and projects on new and renewable sources of energy in the context of overall energy plans by all countries and, in particular, by developing countries;

(e) To provide, as requested and as appropriate, assistance and support for cooperative efforts among developing countries;

(f) To specify measures designed to heighten international awareness of the advantages, potential and economic viability of new and renewable sources of energy, and to support efforts of all countries to take necessary steps to bring about the maximum feasible development of new and renewable sources of energy, taking special account of the stage of development reached in the various technologies and of their socio-cultural and environmental impact.

B. Broad policy areas

4. Five broad policy areas were identified in the Programme for concerted action, all of which involved the support of the international community according to national plans and priorities. They are:

(a) Energy assessment and planning;

(b) Research, development and demonstration;

(c) Transfer, adaptation and application of mature technologies;

(d) Information flows;

(e) Education and training.

C. Areas for priority action

5. According to the Nairobi Programme of Action, priority action should cover the above-mentioned five policy areas. Within each policy area, priority is to be assigned to certain types of actions and programmes which are deemed to require more urgent attention. In particular, meeting the rural energy requirements within the context of integrated rural development programmes is deemed to be of great urgency, especially for developing countries.

II. WORLD ENERGY SITUATION AND PROSPECTS

A. Energy situation and trends

6. Prior to the United Nations Conference on New and Renewable Sources of Energy (1981), world energy consumption was rising very rapidly and wastefully, stimulated by relatively high rates of economic growth, industrialization, and low energy prices; most of the additional demand was being met by the fast growth of petroleum supplies. As a result, pressure was growing on the world's rapidly depleting oil resources which, together with the emergence of certain non-economic factors, brought about the energy crises of 1973/74 and 1979/80, through the interruption of oil supplies and sharp rise in prices.

7. Following the first energy shock (1973/74), while the growth rate of commercial energy consumption of developed market economies declined sharply from the yearly average of 5.0 per cent during 1960-1973 to 1.0 per cent in the period 1973-1979, the corresponding rates for developing countries as a whole went up from 5.3 per cent to 6.6 per cent, with increasing dependence on petroleum supplies. Overall growth rate of global energy production declined from a yearly average of 5.2 per cent to 2.6 per cent, and the growth rate of petroleum declined from 7.7 per cent to 2.1 per cent during the corresponding periods.

8. It is against this background that the Conference was held. The Nairobi Programme of Action, adopted by the Conference, underlined the need for an orderly and peaceful energy transition from a hydrocarbon-based world economy to one based increasingly on new and renewable sources of energy in a manner which is consistent with the needs and options of individual countries, is socially equitable, economically and technically viable, and environmentally sustainable. It was also believed that new and renewable sources of energy could play a very important role in developing countries, especially in rural areas. But for the immediate or medium term, the Conference avoided the consideration of issues related to the future supply-and-demand balances of fossil fuels, particularly oil.

9. The critical global energy climate which led to the subsequent formulation of the Nairobi Programme of Action has been subject to drastic changes, with an unfavourable impact on its implementation. Energy programmes and policies which had been initiated all over the world, under conditions of high oil prices and reduced economic expansion rates, led to reduced energy demand and considerable decline in petroleum consumption, especially after the second energy shock of 1979/80. The success was more pronounced in developed market economies than in developing countries or Eastern Europe. However, excess oil supplies led to lower oil prices, particularly after 1986, with adverse effects on the development of alternative sources of energy, including new and renewable sources of energy.

10. Between 1979 and 1985, the world's energy consumption increased in average by only 1.3 per cent per annum; the rate of increase was 4.6 per cent in developing countries, as compared with minus 0.5 per cent in developed market economies. At the same time, there was a drastic decline in global petroleum demand, as a result of which oil production fell from 65.8 million barrels a day in 1979 to 56.6 million barrels a day in 1985, which was even below its 1973 level. The decline of oil production was especially sharp in the members of the Organization of Petroleum Exporting Countries (OPEC), falling from 30.9 million barrels a day in 1979 to 15.7 million in 1985.

11. The declining global demand for petroleum, on the one hand, and the increasing alternative energy supplies, on the other, brought about excess oil production capacity - mainly in OPEC member countries - and led to a substantial glut in the international markets. As a result, the price of oil, which was around $35 a barrel in December 1980, declined gradually and then fell to under $10 a barrel in mid-1986. Subsequently, it moved up to a range of $18-$20 two years later.

12. The emergence of excess petroleum supplies and the sharp decline in oil prices had a far reaching impact on the global energy scene. The new situation upset energy policies and programmes all over the world by suppressing development of alternative and indigenous sources of energy, discouraging conservation efforts, reducing the trend towards energy self-reliance, and raising again dependence on fossil fuels, particularly petroleum. In other words, by reversal of the 1979-1985 global energy trends, the stage was set for another energy crisis.

13. The efforts made prior to 1986 led to a sharp decline in global energy intensity, but the trend changed subsequently, as may be noted in table 1. In fact, there was a decoupling of the close relationship between economic growth and energy consumption in the developed countries, due to the successful implementation of energy efficiency programmes and structural changes in their economies resulting from the rising share of less energy-intensive service sectors.

14. The developing countries, meanwhile, experienced growing energy intensity and higher energy growth rates, which were due to several factors, including:

(a) An initial low rate of per capita energy consumption;

(b) A higher rate of economic growth, particularly in newly industrializing nations;

(c) A rapid expansion of energy-intensive economic activities;

(d) An increasing substitution of traditional energy sources by commercial energy sources;

(e) A lack of noticeable progress in energy conservation;

(f) Fast growth in population and urbanization.

Table 1. Economic and energy growth rates

(Annual averages, percentage)

	1960-1973	1973-1985	1985-1989
Developed market economies			
GDP	4.7	2.5	3.5
Inland energy consumption	5.0	0.2	1.8
Energy/GDP ratio	1.06	0.08	0.52
Developing countries			
GDP	5.6	3.9	3.5
Inland energy consumption	5.3	5.6	5.3
Energy/GDP ratio	0.95	1.44	1.51
World total			
GDP	4.9	2.8	3.6
Commercial energy production	5.2	1.5	2.8
Energy/GDP ratio	1.06	0.54	0.78

Source: International Monetary Fund.

15. There is wide variation in energy growth rates and intensity among developing countries, and per capita commercial energy consumption remains very low in most of them. For instance, in developing countries of Africa, per capita commercial energy consumption was 178 kg of oil equivalent in 1989, as compared with 455 kg for Asian developing countries and 2,160 kg for Latin America. The corresponding figure for the United States of America was 7,090 kg. However, the consumption of traditional energy sources, which are not included in these figures, played an important role in energy supply of most developing countries.

16. The differences in energy performance between different groups of countries led to considerable shifts in their positions in the global energy consumption picture, with developing countries emerging as the major user of additional world energy supplies. There was little change in the distributive share of each major country grouping in total energy consumption for about 15 years prior to 1973, but in the subsequent years the share of developed market economies declined from 63 per cent to 50 per cent between 1973 and 1989, while the share of developing countries jumped from 15 to 25 per cent. Thus, the major portion of the increments in world energy demand, which used to originate in developed countries, had shifted to developing countries (table 2).

Table 2. Share of country groups in incremental commercial energy consumption

(Percentage)

	1960-1973	1973-1985	1985-1989
Developed market economies	62.3	7.0	35.8
USSR and Eastern Europe	22.2	39.6	15.4
Developing countries	15.5	53.4	48.8
Total	100.0	100.0	100.0

Source: International Monetary Fund.

17. These trends also adversely affected the main objective of energy self-reliance of net energy-importing countries. Table 3 shows that the share of production in commercial consumption of the developed and developing energy-importing countries, after a noticeable rise between 1973 and 1985, started declining in the following years. Hence the share of energy imports of those countries in their consumption began to rise again, leading to increasing dependence on foreign sources of energy, mainly oil supplies.

Table 3. Share of domestic production in commercial energy consumption in net energy-importing countries

(Percentage)

	1960	1973	1985	1989
Developed countries	82.5	57.8	63.9	60.0
USSR and Eastern Europe	100.5	81.8	78.4	74.9
Developing countries	46.5	44.2	62.7	58.7
Total	81.6	58.7	65.4	61.5

Source: Calculated from data given in the United Nations, Energy Statistics Yearbook (various years).

18. Prior to 1973 the major share of the world incremental energy requirements had been met by petroleum supplies and, to some extent, by natural gas. But as the data in table 2 indicate, during the period of active energy policies of 1973-1985, a large part of such need was met through the use of coal and natural gas and, to a smaller extent, nuclear energy, hydropower and other new and renewable sources of energy. In the years since then, however, petroleum - because of its increasing cost attractiveness - has again assumed the leading role in meeting the incremental global energy demand, followed by natural gas and coal, with a limited contribution by nuclear energy and hydropower.

19. In the period following the oil price collapse of 1986 there has been a steep decline in investments in the development and utilization of various sources of energy, including new and renewable sources of energy, petroleum exploration and development, and nuclear energy. However, this reflects not only the impact of lower oil prices but also the adverse effects of other factors, including environmental and financial ones, as evidenced by reduced international bank lending and more stringent conditions for bilateral and multilateral loans and grants. As a result, the dependence on the oil resources of OPEC countries, and especially on the reserves of the Persian Gulf region, continues to grow.

20. With respect to future prospects, global energy demand is expected to grow in the coming decades, along with, inter alia, the rising world population, expansion of economic activities and structural shifts in the developing world towards energy-intensive sectors. The World Energy Conference, at its meeting in 1989, concluded that energy needs would increase by about 75 per cent by the end of the next three decades. It was also agreed that the additional energy needs would be met mainly by coal, petroleum, natural gas, and nuclear energy - i.e., the existing conventional sources of energy. The developing countries, in line with their recent experiences, were expected to register higher energy demand growth rates, compared with other groups of countries, because of their higher rates of population and economic growth, expanding industrialization, and the diminishing availability of traditional energy supplies.

21. Such a scenario for future global energy development will continue to expose the world economy, and especially the economies of developing countries, to great uncertainties of possible energy instabilities. Dependence will continue to increase on rapidly depleting oil and natural gas resources and on coal and nuclear energy, which have aroused great environment concern. It was to avoid such a prospect that new energy policies and programmes had been devised and decisions taken for a gradual move towards an energy transition and increased energy self-reliance.

22. In the circumstances, the transition towards a new world energy mix, with increasing utilization of new and renewable sources of energy and the development of alternative indigenous sources of energy, requires greater attention from the international community. Also, effective measures are needed for the solution of energy problems in rural areas, particularly in developing countries, where half of the world's population live, have little

access to the conventional energy supplies, and are faced - in many areas - with rapid deforestation and desertification. The solution will require new political, social, economic and environmental policy orientations through national action and also cooperation and assistance from the international community.

B. Trends in the production and use of new and renewable sources of energy

23. Over the past 10 years there has been a noticeable increase in the development and utilization of new and renewable sources of energy, including traditional sources. The rate of increase has, however, varied. On the whole, it has been slow, especially since the mid-1980s.

24. World energy production figures for selected years are shown in table 4. The annual contribution of new and renewable sources of energy represents about 13-14 per cent of total energy supplies. 3/ Firm figures on production of new and renewable sources of energy, in particular traditional sources, are very difficult to come by. While in some countries, significant and systematic efforts have been made to compile relevant data, there is still a long way to go. It is also difficult to combine figures from disparate sources. Further details on individual sources of energy are contained in respective background documents.

Table 4. World energy production, 1981, 1985 and 1989

(Millions of metric tons of oil equivalent, c.f.e.)

	1981	1985	1989
Petroleum	2 923	2 822	3 098
Natural gas	1 276	1 436	1 707
Coal	1 812	2 079	2 231
Nuclear energy	226	416	451
Renewable sources a/	916	1 067	1 183
Total	7 153	7 820	8 670

Source: State of the World, 1991. Figures for 1989 are from Worldwatch Institute (Washington, D.C.).

Note: The conventional fuel equivalent (c.f.e.) for nuclear energy, hydropower, geothermal, wind and solar thermal energy sources reflects their energy output on the basis of the amount of oil that would be required to produce electrical energy form a thermal power station assumed to operate at an efficiency of 30 per cent.

a/ Including estimates for small-scale hydropower, oil-shale, alcohol, vegetal and animal residues, fuelwood, charcoal, wind and solar energy production.

25. Table 5 shows data on the consumption of major energy sources in developing regions in 1981 and 1985. As can be seen, the share of new and renewable sources of energy consumption in developing regions has remained largely unchanged over the period. In those regions, new and renewable sources of energy provide an average of some 30 per cent of consumed energy - approximately 57 per cent in Africa, 38 per cent in Latin America and 20 per cent in Asia and the Pacific. Figures for 1985 to 1990 are unavailable.

Table 5. Energy consumption in developing regions, 1981 and 1985

(Millions of metric tons of oil equivalent, c.f.e.)

	Africa		Latin America and the Caribbean		Asia and the Pacific		Total	
	1981	1985	1981	1985	1981	1985	1981	1985
Petroleum	51	61	205	197	290	348	546	606
Natural gas	14	16	57	65	49	74	120	155
Coal	5	5	16	20	434	595	455	620
Nuclear energy a/	0	0	1	2	4	14	5	16
Renewable energy b/	93	109	143	176	226	226	462	551
Total	163	191	422	460	1 003	1 297	1 588	1 948

Note: The conventional fuel equivalent (c.f.e.) for nuclear energy, hydropower, geothermal, wind and solar thermal energy sources reflects their energy output on the basis of the amount of oil that would be required to produce electrical energy from a thermal power station assumed to operate at an efficiency of 30 per cent.

a/ Production figures.

b/ Production figures and expert estimates.

26. Table 6 shows world production figures for hydropower, geothermal electricity generation and direct use, peat, oil-shale, alcohol and bagasse, for which statistical data are available, and for vegetal and animal residues, fuelwood and charcoal, for which estimates have been prepared. Preliminary estimates have also been given for wind energy and solar thermal energy.

Table 6. World production of new and renewable sources of energy, 1981 and 1985

(Millions of metric tons of oil equivalent, c.f.e.)

Energy source	1981	1985
Large-scale hydropower	500.6	571.0
Small-scale hydropower	..	14.0
Geothermal - electricity	4.2	6.7
Geothermal - direct use	..	12.6
Peat	9.9	5.4
Oil-shale	8.0	7.2
Alcohol	2.8	7.9
Bagasse	33.4	51.1
Vegetal and animal residues	..	9.7
Fuelwood and charcoal	457.5	511.7
Wind - electricity	..	0.3
Solar thermal	..	..
Solar photovoltaic	..	..
Total	1 016.4	1 197.6

Source: "Geothermal energy development (NRSE/IGM/BP/1); "Tar sands and oil shale" (NRSE/IGM/BP/2); "A decade of wood energy activities within the Nairobi Programme of Action" (NRSE/IGM/BP/7).

Note: The conventional fuel equivalent (c.f.e.) for nuclear energy, hydropower, geothermal, wind and solar thermal energy sources reflects their energy output on the basis of the amount of oil that would be required to produce electrical energy from a thermal power station assumed to operate at an efficiency of 30 per cent.

27. Hydroelectricity production increased by about 17 per cent during the period 1981-1989. Small-scale hydropower, for which no data was available in 1981 but which has grown recently, now represents a non-negligible supply of energy in excess of that obtained from alcohol or peat.

28. Geothermal energy production, still small in absolute terms, increased by 60 per cent during the period 1980-1985, and has increased 48 per cent since that time. This increase reflects active development in such countries as Kenya, Mexico and the Philippines.

29. The production of peat and oil-shale declined by some 30 per cent between 1981 and 1985, and since then, affected most likely by the direct competition of other fuels, may have declined further - oil-shale in particular.

30. The output of energy alcohol nearly tripled, reflected by the rapid expansion of the Brazilian programme of gasoline substitution. Energy from bagasse increased by some 53 per cent during the period 1980-1985 and is used in the form of steam and process heat by the sugar industry and for electricity generation. No figures are readily available for the past five years.

31. Traditional sources of energy, which include fuelwood, charcoal, draught animal power and agricultural and animal residues, represent the largest share among new and renewable sources of energy. Energy supplies from fuelwood and charcoal are estimated to have provided the equivalent of over 500 million metric tons of oil in 1985 and 377 in 1990. The increased use of fuelwood, charcoal and agricultural and animal residues for energy in developing countries results in a deterioration of living and environmental conditions.

32. It appears that, during the first half of the decade, large-scale applications of mature technologies such as hydropower and geothermal electricity progressed significantly. They have, however, slowed down since 1985. Regarding small-scale applications, numerous activities have taken place; however, their overall impact on the global availability of energy remains insignificant.

III. PROGRESS ACHIEVED IN THE IMPLEMENTATION OF THE NAIROBI PROGRAMME OF ACTION DURING THE 1980s

A. Overall assessment

33. The task of making an assessment of the progress achieved in implementing the Nairobi Programme of Action is difficult because of the multidimensional character of the Programme involving 14 sources of energy, a variety of actions at different levels in five policy areas and certain priority areas, specific technical and financial measures, decentralized methods of implementation, and the participation of different organizations at the national and international levels, public and private, etc. There are no technical and/or financial targets stipulated in the Programme. It is therefore necessary to consider both qualitative and quantitative aspects in making an assessment of progress achieved.

34. At the national level, several countries have made significant progress, notwithstanding the fact that they faced severe economic constraints during the past decade. In a supportive role, the United Nations system has undertaken wide-ranging activities in order to assist countries in their own efforts.

1. Energy assessment and planning

35. The following measures are called for in the Nairobi Programme of Action:

(a) Map, survey and undertake other appropriate activities to determine the full range of physical resource endowment, using, wherever possible, standardized technologies for data collection, processing, storage and dissemination;

(b) Determine in a dynamic way, energy supply, demand and energy balances, including projection of future energy requirements;

(c) Identify and keep under review mature and near-term promising and ongoing research, development and demonstration activities and assess their economic, socio-cultural and environmental costs, potential and benefits;

(d) Strengthen and/or establish institutional infrastructure to collect, maintain, analyse, classify and disseminate information on all the above and pertaining to policy, programme and project decision-making process; the legislative framework and related procedures (and their impact on energy supply and use patterns), and the availability of financing.

36. During the 1980s, the attention given to and the progress achieved in the area of energy assessment and planning world wide has been substantial. Most developing countries have taken steps to develop energy policies and plans appropriate to their needs and special circumstances. Nevertheless, progress on the incorporation of new and renewable sources of energy in national energy plans and programmes and development of an integrated approach to energy planning has been slow. Actions, however, vary from country to country. A number of countries, have not only improved the database pertaining to energy demand and supplies but also made significant progress in building up data infrastructure for new and renewable sources of energy and in evolving standardized methodologies for data collection and processing. In those countries, data and feedback from ongoing programmes are providing a basis for assessing the possible role of new and renewable sources of energy as well as for decision making with respect to the evolution of integrated national policies and plans. Significant progress has been made on surveys to obtain data on solar, wind and biomass (including fuelwood and agricultural residues) and hydropower resources and on the assessment of geothermal potential. Many developing countries have been assessed for wind, biomass, fuelwood, charcoal and hydropower and other new and renewable sources of energy potential.

37. In recent years, interest has grown because of the environmentally favourable dimension of new and renewable sources of energy. But this has not been adequately translated into energy policy and planning exercises. The serious nature of the fuelwood problem and the environmental consequences of unplanned utilization have prompted countries to bring this matter within the ambit of national energy planning. Supportive action undertaken by the entities of the United Nations system have been well received by the developing countries. In particular, the joint UNDP/World Bank energy

assessment and Energy Sector Management Assistance Programme activities, and the technical cooperation of many other entities of the United Nations system, including regional commissions, have been successful in assisting many countries in determining critical areas of policy and planning and in evolving appropriate measures to better manage the energy sector.

2. Research, development and demonstration

38. The following measures are called for in the Nairobi Programme of Action:

(a) Select promising technologies with a view to launching concerted efforts to accelerate their development, increase their cost effectiveness and widen their applicability;

(b) Identify the research needed concerning the economic, social and environmental implications of emerging technologies, including employment potential;

(c) Establish or strengthen institutional machinery and national and regional capacity, including the private sector, where appropriate, for undertaking and coordinating research, development and demonstration activities, on the basis of a review initially to be undertaken at national, subregional and regional levels of present capabilities and existing resources to respond to identified needs and priorities, in particular to those of developing countries; this review could later be extended to the global level with a view to the consideration of the need for a global research and development network around one or several lead institutions;

(d) Establish or strengthen institutional machinery to provide links between research and development activities and the production sector (public investments, industrial property systems etc.);

(e) Consider the establishment of testing programmes to increase the ability of prospective consumers; producers and investors to make informed decisions regarding technological options;

(f) Establish criteria for technical and economic evaluation of new technologies that will help national experts to identify their potential at specific locations;

(g) Identify and implement demonstration projects relating to new and renewable energy technologies, including those which can be undertaken on a collaborative basis, taking into consideration the benefits in terms of stimulating further related research and development, the training of specialists, and increased industrialization.

39. Of the numerous research, development and demonstration activities undertaken world wide, most have been pursued in the developed countries and a

few developing countries. Brazil, China, Egypt, India and Thailand have, for example, built up research infrastructure and undertaken national-level demonstration projects. Projects undertaken in developing countries under bilateral and multilateral cooperation have had rather limited objectives of testing of equipment or devices developed elsewhere and therefore have not had an impact at the national level. While some projects undertaken by the United Nations system have focused on strengthening the national research and development capabilities, the kind of research, development and demonstration activities identified in the Nairobi Programme of Action did not emerge. A few developing countries, notably China and India, have taken action to strengthen research and development capabilities by establishing research centres for different subject areas, including wind, biomass and hydropower, but other developing countries need substantial assistance to build up their research, development and demonstration capabilities.

40. In spite of the continuous decline in financial support for undertaking research, development and demonstration activities in developed countries over the past 10 years, significant progress has been achieved in solar, wind and biomass technologies. The progress achieved is in no small measure attributed to the momentum generated and support given to research, development and demonstration in the developing countries during the period leading to the Nairobi Conference and immediately thereafter. Most of those countries sponsored demonstration projects in developing countries under bilateral cooperation programmes. The expectation that such demonstration projects would lead to the development of markets for specific technologies and possible technology transfer has not been borne out, perhaps because of the subcritical size and limited scope of such projects and lack of effective follow up. Moreover, research collaboration between developed and developing countries was not pursued to the extent needed for promoting technology transfer. The linkage between research, development and demonstration and technology transfer and commercialization failed to take root since most of the demonstration projects were pursued as an end in themselves rather than as means to facilitate technology transfer.

41. In the developed countries, solar thermal, photovoltaics, wind energy and, to a lesser extent, biomass have received the largest share of the total funding for new and renewable sources of energy research, development and demonstration. Research, development and demonstration in solar thermal technologies has led to the development of a range of solar collector technologies from flat-plate systems to those used in industrial and power generation systems. Demonstration projects have not been free from failure and criticism. The main criticism stems from the lack of effective follow-up to assist countries to carry out the full range of activities to attain proficiency in the demonstrated technology and to achieve indigenous capability through transfer and/or adaptation of that technology. Exceptions are wind power projects in India funded by Denmark and a UNDP-assisted project in Egypt. The project in India involved installations of wind farms of 20 MW aggregate capacity. It has strengthened local capabilities and led to technology transfer and local manufacture; so has the project in Egypt. While

research, development and demonstration projects undertaken by the United Nations system have tried to extend technical support to research centres and implemented a few development-cum-demonstration projects in some countries, their impact at the national level would be felt only if such activities were constantly reinforced and sustained over a period of time. This would require such activities to be planned as integral components of a more comprehensive programme, with better linkage among the different elements than has been achieved so far. Technical and cost goals will need to be considered alongside the objectives of the research, development and demonstration activities as envisaged in the Nairobi Programme of Action. More funds are needed to initiate action on all the specific measures identified in the Nairobi Programme of Action.

42. At regional level, the establishment and strengthening of regional centres and networks will provide the basis of promoting cooperative research in this area. The activities undertaken so far by ESCAP, ECLAC and ECE have indeed contributed to establishing the basis for such regional cooperation joint research involving information exchange.

3. Transfer of technology, adaptation and application of mature technologies

43. The following measures are called for in the Nairobi Programme of Action:

(a) Identify and keep under review with respect to mature technologies utilizing new and renewable sources of energy their role within sectoral programmes and, where appropriate, establish or strengthen institutional arrangements to promote their application;

(b) Strengthen and/or establish measures to promote and facilitate the accelerated transfer of technology on new and renewable sources of energy, especially from developed to developing countries, in order to enhance the contribution of these energies to the total energy supply of developing countries;

(c) Support measures to increase economic and technical cooperation among developing countries, including the undertaking of joint programmes of activities;

(d) Develop national capabilities to undertake, inter alia, the manufacture, adaptation, management, repair and maintenance of devices and equipment related to technologies for the assessment and utilization of new and renewable sources of energy;

(e) Strengthen the ability of developing countries to make financial and technical evaluations of the different elements of the technologies, thereby enabling them to better assess, select, negotiate, acquire and adapt technologies required in order to utilize new and renewable sources of energy;

(f) Formulate innovative schemes for investments related to manufacture of equipment for new and renewable sources of energy, including the establishment of joint industrial programmes among interested countries of the manufacture and commercialization of capital goods;

(g) Strengthen national capacity to review and assess domestic, fiscal, regulatory, socio-cultural and other policy aspects required to accelerate the introduction of technologies related to new and renewable sources of energy;

(h) Support, as appropriate, demonstration projects related to the application of new and renewable sources of energy technologies prior to a decision on commercial operation and widespread implementation.

44. Activities undertaken to promote technology transfer have been few and somewhat sporadic. Efforts have been made to bring together entrepreneurs and research entities by organizing exhibitions, seminars and preparation of joint venture proposals. International expositions and exhibitions have no doubt created greater awareness and enabled interactions among those interested in transferring and those in acquiring new and renewable sources of energy technologies. Some joint ventures in solar heating, photovoltaics, hydro, geothermal and biomass technologies have materialized, largely through private-sector initiatives. However, organized effort aimed at increased promotion of and support to activities contributory to technology transfer have not been forthcoming. This may be due to inherent limitations involved in technology-transfer transactions.

45. In some developing countries, national-level promotional measures, including incentives and improved licensing arrangements, have spurred private-sector initiatives. Demonstration projects were expected to facilitate technology transfer, but most of them lacked proper follow-up. They failed to establish linkage with the institutional elements critical for successful technology transfer. Nevertheless, in those countries with strong local research and development base and entrepreneurial initiatives, transfer of technology has taken place. In countries like Brazil, China and India the necessary technology base in new and renewable sources of energy exists and can absorb more modern technologies and adapt them to suit local conditions.

46. Transfer-of-technology-related activities for cooperation among developing countries have technically been less common. However, more open exchange of information on biogas, improved wood stoves, gasifiers and solar devices have contributed a great deal to adaptations to suit local conditions and to increased availability of such devices. Several countries have started major programmes with regard to progress achieved in the application of mature technologies which, if pursued with greater vigour and support from financial establishments within and outside those countries, could make a significant impact.

47. There has been a slowing down of application programmes in developed countries. Only some of these programmes have achieved the objectives of

promoting applications of mature technologies. At the multilateral level the applications of mature technologies, such as Brazilian alcohol programmes and several hydropower and geothermal projects, have been assisted by the World Bank and regional banks, but beyond those, very few projects have been undertaken.

4. Education and training

48. The following measures are called for in the Nairobi Programme of Action:

(a) Support national efforts to estimate the requirements for the various categories of trained personnel;

(b) Assess the capabilities of existing institutions to undertake the training of required personnel, and strengthen institutional infrastructure accordingly, paying special attention to the training of teachers and trainers;

(c) Coordinate and promote the exchange of information on educational systems, teaching materials, training programmes and technical experience relating to new and renewable sources of energy, between developed and developing countries and particularly among developing countries;

(d) Support efforts directed at the establishment or strengthening of national, subregional and regional training and educational centres;

(e) Establish training programmes for decision makers, planners, managers and extension workers;

(f) Establish programmes to increase the awareness of the general public of the opportunities that exist for using new and renewable sources of energy, especially in small-scale, decentralized applications, involving the general educational system and the mass media so as to ensure the full and effective participation of the entire population at all stages of the development process.

49. At the national level, education and training activities have scarcely increased; most of the activities are linked to specific programmes. The activities have not yet resulted in the incorporation of new and renewable sources of energy in the education system, starting from primary school all the way to colleges and technical and vocational schools. The lack of adequate attention to this area has to some extent affected public acceptance of technologies and hindered public participation in the design and implementation of new and renewable sources of energy programmes.

50. A few countries have taken action to introduce optional subjects on new and renewable sources of energy at Bachelor and Master degree programmes and specialization in new and renewable sources of energy areas. Employment opportunities for countries with such specializations are still uncertain; consequently, there is reluctance on the part of candidates to specialize in new and renewable sources of energy. Consequently there is also insufficient

emphasis on the interdisciplinary nature of new and renewable sources of energy technologies and their utilization. The educational process must also demonstrate the role new and renewable sources of energy in development and the interlinkage with the development sectors and activities.

51. The progress achieved at the bilateral and multilateral levels on the promotion of human resources development is mainly through incorporation of training and educational activities into the programmes and projects executed by donor countries and by the United Nations system. These have also included fellowships, study tours, training workshops, and participation in international conferences.

52. Manpower assessment and training studies undertaken by ILO have provided guidelines for estimating manpower requirements for specific activities. FAO has incorporated training aspects in the wood energy and rural energy activities undertaken by them. In regional commissions, ESCAP, ECLAC and ECE have made significant contributions in promoting education and training through regional training workshops and network activities. Educational activities of many entities of the United Nations system have reflected increasing interest in environmental issues, women's welfare and social and cultural factors in relation to development. Progress made by such studies will enable incorporation of these issues in greater measure into energy programmes in the future.

5. Information flows

53. The following measures are called for in the Nairobi Programme of Action:

(a) Identify currently available information systems and services and assess their capability to provide the required categories of information on the development and utilization of new and renewable sources of energy, in a manner and form suitable to different types of users, taking into account existing studies in that area;

(b) Establish and/or strengthen national, subregional and regional energy information centres, preferably based on existing data banks or with institutions of research and learning, with related programmes of workshops, seminars and other information services, and integrate them into regional networks, which could later be joined into a global information network, where and when it may be deemed necessary and feasible;

(c) Develop and make use of standardized methodologies, terminologies, procedures and, where feasible, equipment (software and hardware) for the collection and dissemination of information to facilitate the linkage of data centres and systems;

(d) Support measures which ensure the maximum availability of technological information contained in patent documents.

54. Progress has been made on the linking of existing information systems, services and sources of the United Nations system. The Information Network on new and renewable sources of energy and Technologies in Asia and the Pacific was established by UNESCO, which has played a key role in the interconnection of data banks, flow involvement of non-governmental organizations, and the design of uniform formats for information compilation. These have contributed to improved access to documents generated in the developing countries, by providing and distributing ASSET and by providing assistance to various information activities, including document procurement, review and evaluation, and maintaining links with other entities of the United Nations system. Despite all these, there is a great deal of scope for vastly improving information flows in the areas identified in the Nairobi Programme of Action.

6. Rural energy supplies

55. The Nairobi Programme of Action recognized that in rural development, energy was a priority. In developing countries, most of the energy in rural areas is based on traditional sources such as fuelwood, crop residues and dung. Commercial sources such as coal, oil, and gas account for less than 25 per cent of rural energy consumption. The population is growing fast in both rural and urban areas, and the pressure on traditional sources of energy, such as fuelwood, is excessive and environmentally destructive in many parts of the world. The pressure is not expected to lessen in the foreseeable future, in spite of the great migration to urban areas.

56. Rural energy has been the focus of attention in many countries. Rural energy surveys have been undertaken covering a large number of villages in Asian and African countries, and they have provided data on the energy consumption patterns and the availability of local resources and have indicated the scope for the introduction of the new and renewable sources of energy technologies, plans and programmes needed to promote them. The institutional and management aspects have also been examined in those countries.

57. Progress in the area of integrated rural energy development has been significant, as evidenced by the number of activities which have been undertaken covering various aspects of the rural energy situation. FAO has made concerted efforts to focus attention on the new approach needed for integrated rural energy planning, emphasizing the role of new and renewable sources of energy in agricultural production, draught animal power, post-harvest applications, wood energy, biogas, cook stoves, water lifting and agro-industry, among others. Preliminary work has been done on the development of integrated rural energy systems at the village and community levels. Planning studies and pilot integrated rural energy projects have been undertaken in several countries which have provided insights into the relevant technical, economic and social parameters for decentralized energy planning. Such actions have been directed towards identifying the prospects for near and long-term applications of new and renewable sources of energy and their potential contribution to national energy balances.

B. Specific new and renewable sources of energy

1. Solar energy

(a) Assessment and planning

58. The solar radiation intercepted by the earth represents an enormous amount of energy.

59. Some effort has been made at measuring and estimating solar irradiance. WMO has been active in providing technical assistance and undertaking relevant studies. Additional effort is, however, required to cover those areas that have not been sufficiently surveyed and to develop simple and practical methodologies of translating scientific information into engineering design or presenting the data collected in a manner amenable to easy use for engineering and design applications. There is also need to evolve approaches for assessing solar energy resources as an integral part of new and renewable sources of energy and overall energy resource assessment.

60. The outlook for solar energy is bright, although it is sometimes dismissed as uneconomic when compared directly to fossil fuels. However, such assessment should not be based simply on traditional or conventional economics but must include a consideration of suitable or environmentally attractive energy-generation technology. The advantages of solar energy options then become clearer.

(b) Research, development and demonstration

61. Solar thermal energy conversion systems are the most mature technologies, incorporating ideas developed long ago; however improvements are still being made. The development process is continuing to promote the production of locally made affordable low-temperature solar heating systems. Other areas of development work cover particular problems or needs of different countries - e.g., solar desalination. Significant progress has been made in the development of solar collector technologies, particularly concentrators, and auxiliary systems for improved efficiencies and for component reliability under different climatic and operating conditions.

62. Research and development designed to improve overall efficiencies of solar thermodynamic conversion systems is dedicated to improving collector efficiency to raise the working fluid temperature. New stressed-membrane heliostats have been developed and are now in production. They have both improved initial reflectivity levels and are capable of sustaining them over a number of years.

63. The main thrust of further development is centred around the reduction of costs for solar thermodynamic electricity generation. Generating costs at the newest power plants of Luz International Ltd. are about $US 0.08/kWh. A demonstration plant is currently being installed at the Scandia National Laboratories, using molten salts as the heat transfer fluid, and work already

carried out shows that a 200 MW plant would generate electricity at costs competitive with fossil fuelled plants. However, initial plans are concerned with the construction of a 100 MW demonstration plant.

64. Over the past 15 years, the price of photovoltaic modules and systems has been steadily falling in real terms, while module efficiency has risen, and heightened awareness of global warming problems has increased the hidden costs of fossil fuel projects.

65. Significant research, development and demonstration programmes on photovoltaic technologies have been initiated internationally since the mid-1970s. In recent years particular interest has been shown in large-scale photovoltaic electricity generating plants in Europe, Japan and the United States. There is also a substantial research, development and demonstration effort by private industry, on which published information is not readily available. In addition, there are expected to be spin-off benefits for photovoltaic technology from research, development and demonstration in related areas (notably, the semiconductor and microelectronics industries).

66. Three main subjects of interest are the enhancement of cell efficiencies; reduction of costs (the ultimate aim of most industrial research, development and demonstration; understanding the basic physics of inhibition of degradation process for amorphous silicon cells; and devising new semiconductor doping materials which may inhibit the rate of destabilization.

(c) Transfer, adaptation and application of mature technologies

67. A large project is being funded by EEC as a component of the Sixth European Development Fund regional programme to combat desertification in the Sahel and West Africa. Funds have been allocated for the procurement of photovoltaic pumping systems and related equipment for water and electricity supply in the Sahelian countries. The total installed capacity will be around 1.3 MW.

68. The evaluation of photovoltaic technologies and markets are closely interdependent; it should be noted, however, that while there is a link between cost/price and market size, it cannot be assumed that a reduction in price will lead to a larger market.

69. A photovoltaic system is a relatively new technology. None the less it is beginning to make a significant impact, particularly for rural applications in developing countries. There are now in use tens of thousands of photovoltaic-system lights, minimum photovoltaic pumping units, vaccine refrigerators, navigational aids and telecommunication power supplies.

70. The price of photovoltaic systems has come down by a factor of three over the past 10 years and the efficiency has almost doubled; this general trend is expected to continue in the future. Photovoltaic systems are now economic (in sunny regions) for most off-grid applications where less than 25 kWh/day of energy is required, and they are expected to become increasingly economical, and even grid connected, for larger applications.

71. Despite a long history of their use, solar engines for small-scale mechanical power such as grinding, milling and water-pumping have not yet reached the stage where economically viable equipment is commercially available. Although research and development continues, the relatively large user intervention required for operation has led to the belief that other renewable energy technologies such as photovoltaics, wind and hydro will always compete favourably against solar engines. Favourable experiences with several grid-connected solar power stations in California have proven the technical feasibility of such stations on a large scale. Costs are at present comparable with those for other energy technologies. Consideration is being given to the application of this technology in Brazil and India and a number of other developing countries. Improvements in the efficiency and reductions in cost have been modest in comparison with photovoltaics, but further advancement and improvements are expected in the future.

72. The economics of solar heat technology are site-specific. When environmental costs are taken into consideration, solar water-heating is mainly economic, but in some countries its competitiveness is often masked by subsidized electricity and fossil fuel energy prices. The economics of solar electricity produced thermodynamically is less clear for developing country economies, but reported costs for electricity from solar-powered plants in California are promising. The viability of solar photovoltaic power stations is, however, based on the price forecasts of future photovoltaic systems. Small-scale photovoltaic systems for communications, lighting and other stand-alone applications have been widely used in different parts of the world, including developing countries. Negotiations and consultations for the manufacture of photovoltaic systems in a number of developing countries are already in advanced stages.

2. Wind

(a) Assessment and planning

73. Most of the wind energy for electricity production is concentrated in the United States and Europe. Approximately 20,000 wind turbines for electricity generation have been installed to date; the bulk of them are in California. Experience suggests that the most economical turbines are those with ratings between 50 and 350 kW.

74. The focus of development has now shifted to Europe and some developing countries. Most European Governments are subsidizing wind energy development as a result of environmental concerns and the security of supply. Denmark has, for example, instituted incentives and legislation for encouraging privately owned grid-connected turbines, and plans are well under way to install 100-MW wind farms by 1991. It now has a total of 200 MW of installed systems, the most in Europe. The Netherlands has 40 MW installed and 100 MW in the pipeline, while Germany hopes to install 100 MW by 1994. The United Kingdom has proposals for 500 MW; Greece has 10.5 MW under order, and Sweden has 8 MW installed and a large potential.

75. The Commission of the European Communities sponsored a study in 1986 on the wind resource potential in Europe which identified many sites with a potential annual electricity production of approximately 4,000 TWh/annum. In 1989 it published a European wind atlas and a preliminary map of the Mediterranean basin. Handbooks on solar and wind data and atlases have also been published by countries in Asia.

76. India has set up 300 wind-measuring stations throughout the country and has estimated its wind potential to be in excess of 25,000 MW. China has undertaken similar assessments. Under a UNDP project, 29 developing countries have been assessed for wind potential. The Department of Technical Cooperation for Development of the United Nations Secretariat has undertaken an assessment of wind power potential in Mauritius.

(b) Research, development and demonstration

77. Research, development and demonstration activities in wind have mostly been confined to industrialized countries. In the past four to five years there have been attempts undertaken in joint development and demonstration activities in China, Egypt and India with bilateral/multilateral assistance. Meanwhile, the Department of Technical Cooperation for Development of the United Nations Secretariat has given support to selected national research and development institutions, some of them involving wind technologies. ESCAP has also initiated several wind demonstration projects, often accompanied by expert group meetings, while ESCWA has supported demonstration projects involving wind power. ESCAP publishes technical documents and has established a biomass/solar/wind energy network and publishes a newsletter in order to strengthen local research capabilities.

78. Five demonstration wind farms were established in India, in 1986 - in Gujarat, Tamil Nadu, Orissa and Maharashtra, with a total capacity of 3.3 MW. The installed capacity at the five wind farms has since been raised to 5.5 MW.

79. Some demonstration projects in developing countries have failed, mainly as a result of lack of effective follow-up in carrying out the full range of activities. A number of projects have, however, led to strengthening of local capabilities, technology transfer and local manufacturing - for example, in India (funded by Denmark under a bilateral agreement) and Egypt (funded by UNDP). Future developments will probably focus on materials, including glass-reinforced polyester blades, and machine processes such as transverse filament tap blades; mechanical designs incorporating increased flexibility and compliance in blades and rotors to reduce weight and costs; and aerodynamic designs leading to increases in blade thrust and taper and new airfoils.

(c) Transfer, adaptation and application of mature technologies

80. Most of the large wind-power systems are for electricity generation. Markets for irrigation or low wind speeds are largely undeveloped. European and Japanese companies have gained valuable demonstration experience largely through their involvement in developing the California wind farm market: half of the turbines sold to California were designed and manufactured in Europe.

81. In China, wind turbine generators from 14 different countries, ranging from 24 W to 200 KW, have been introduced. In order to accelerate larger wind energy exploitation, demonstration programmes were established. They included Danish and Swedish 150-KW wind-turbine generators, all of which were connected to local grids. In India over 15 million units of electricity are generated and fed to the state electricity grids at a cost on the same order of magnitude as that for power from thermal power stations. Six more wind farms with an installed capacity of 5.5 MW have been installed.

82. Several developing countries on the Mediterranean have installed wind turbines. Algeria has developed a hybrid system consisting of a diesel generator, photovoltaic panels and a 1kW wind-turbine generator 3 metres in diameter. In Egypt, several wind turbines are in operation for water desalination and electric-power generation. Morocco has a number of small-size wind turbines in service, and in Tunisia wind turbines connected to local electric grids are in use.

3. Biomass

(a) Assessment and planning

83. The relative share of biomass, comprising fuelwood, charcoal, crop residues and animal wastes, in total energy consumption has been decreasing world wide over the past decade. At present, it constitutes about 20 per cent of the developing countries' total energy consumption. Large differences in the share of biomass exist in different regions and in countries within a

region. It is estimated that biomass constitutes 60 per cent of the total energy consumption in Africa, 40 per cent in Asia, 30 per cent in Latin America and 10 per cent in Europe, the Middle East and North Africa. In many countries of Asia and Africa, however, 80-90 per cent of household energy is supplied by biomass. It is thus crucial for basic needs.

84. A majority of developing countries have taken steps to assess the biomass resources base, consumption and supply as part of their national energy balances, household expenditure surveys, national household energy surveys and local micro surveys. Data availability has improved somewhat; nevertheless, biomass still does not figure in the energy plans and programmes of a number of developing countries, in terms of demand and supply balances.

85. There exists considerable scope for improving data-collection techniques and data reliability in developing countries. In contrast, the database on biomass resources in developed countries has become well established, since its use is largely commercial. Data on fuelwood and agricultural residues are compiled by FAO on the basis of information supplied by Governments. A handbook of such data is published annually. The joint UNDP/World Bank energy assessment and ESMAP activities have also focused on an assessment of biomass in several developing countries - primarily fuelwood, charcoal and bagasse.

86. Biomass resource assessment and planning in the context of energy has remained peripheral to the main activities of institutions/ministries engaged in agriculture, forestry and energy, with no single agency being generally responsible for the overall effort. Other constraints such as non-commercial use, seasonal availability, variation in type, quality and pattern of use, competition from other sectors, etc. have rendered planned efforts difficult. Planning biomass supply for industrial use and power production has faced constraints due to the unfavourable economics of biomass production and utilization in the face of low oil prices.

87. Nevertheless, many local situations still present favourable economies for biomass. Consumption of fuelwood exceeds sustainable supply in a large number of developing countries. The rural areas of developing countries continue to be under severe biomass stress, and appropriate national policies and planned efforts are considered essential in order to improve the situation.

88. An assessment of agricultural residues has been carried out in a number of countries in Asia, Africa and Latin America. The assessment of forest residues has not progressed to the same level as that of agricultural residues. Estimates of the availability of rice, wheat and other grain stalks, rice husk, coffee husk, groundnut shells etc. are available in many countries. While the estimates are provided by the countries themselves, activities undertaken by FAO on rural energy planning and wood energy, by the Department of Technical Cooperation for Development of the United Nations Secretariat on biomass assessment as part of its ongoing programme of assistance to countries in energy planning and by UNDP/World Bank under its energy assessment and ESMAP activities have enhanced assessment and planning capabilities in the crucially important areas of fuelwood, charcoal, agricultural resides and animal wastes.

(b) Research, development and demonstration

89. Basic research on biomass production has expanded significantly during the past 10 years. Research and development on fast-growing species of plants suitable for different agro-climatic regions have been undertaken by several developing countries - notably China, India, Indonesia, the Philippines and Thailand - and developed countries. These activities have resulted in better knowledge of specific plant species, growth rates and yields, agro-cultural practices for specific species, harvesting, transport and storage aspects, and relative costs.

90. Research, development and demonstration on bioconversion technologies have been vastly expanded in several countries. Between 1983 and 1988, over 1,000 research, development and demonstration activities on such technologies were undertaken world wide, covering gasification, pyrolysis, liquefaction, carbonization, power generation, system studies etc. The bulk of these activities were in the United States of America (35 per cent) and Europe (42 per cent) but a sizeable number were in Asian countries (China, India, Indonesia and Thailand - 16 per cent) and Brazil (3 per cent). Africa accounted for only 2 per cent of all such activities in this field.

91. Research, development and demonstration on biomass gasification have attracted the greatest attention. Current efforts in developed countries are on advanced gasification processes, methanol synthesis, and catalysis. Developing countries have focused their efforts on small-scale gasifiers suitable for rural uses and capable of working on a variety of agro-residue feedstocks. Progress has been achieved in pyrolysis. Significant progress has been achieved in the ligno-cellulosic conversion process.

(c) Transfer, adaptation and application of mature technologies

92. Application of mature biomass technologies such as ethanol and methanol production and direct combustion technologies for heat and power production seemed well poised to penetrate developing countries, especially after national agencies and multilateral financing institutions financed the large-scale ethanol programme in Brazil and dendrothermal power programme in the Philippines. However, there has been a set-back in these applications, and further progress has been adversely affected. The drop in oil prices has reduced their economic attractiveness. In the case of the dendrothermal programme, techno-management problems have hampered progress. Nevertheless, some developed countries - notably the United States, Denmark and Sweden - have made increasing use of biomass residues for industrial and power generation, as is evident from capacity additions of about 400 MW in the past 10 years.

93. The densification of biomass to produce pellets and briquettes has been well established in Europe. However, the application of this technology on a large scale in developing countries has faced technical and marketing problems. Projects have been undertaken in some countries with bilateral aid and with assistance from multilateral agencies, but the technologies supplied

have not been suitably adapted nor has assistance been given for local manufacture. However, in Brazil and India where local capabilities for manufacturing equipment exist, densification technology is beginning to be applied and is well poised for further expansion. Thailand tried to introduce briquettes made out of agricultural residues on a large scale but found them to be too expensive for most purposes, except for some specialized markets. The use of charcoal briquettes, or biocoal, is gaining ground in Thailand as an alternative to wood charcoal, based on cost considerations. The production of charcoal briquettes from sawdust in Thailand and from coffee husks and cotton stalks in Kenya has been successful and has started to make inroads in the domestic sector.

94. Since 1980, a number of countries have implemented fuel alcohol programmes. The largest is in Brazil, where 10 billion litres of ethanol are produced annually. In Africa, plants in Kenya, Malawi, Mali and Zimbabwe produce ethanol from molasses to substitute for 3-15 per cent of the domestic demand for gasoline. Support for ethanol programmes in other countries - notably, the Philippines and Thailand - has been held back because the economic viability is not strong in present circumstances. The Brazilian Government has announced a suspension of expansion of its fuel-alcohol distilling capacity. The programme has become, in economic terms, marginally viable because of the drop in oil prices. The viability of fuel alcohol can be increased by integrating distilleries with sugar mills so that surplus bagasse can provide process energy for alcohol production.

95. Feeding surplus power to the electric grid through the application of bagasse cogeneration systems is receiving attention in many developing countries. A preinvestment study has been completed for India by the World Bank, and studies for sugar mills in Ethiopia and Guyana have been made. Various options for improving economic viability have been examined. Substantial progress has been made in the application of biogas technology based on animal wastes. China and India together account for the bulk of the 6 million-7 million small-sized plants installed world wide so far. Applications of biogas are also seen in Nepal, Thailand, and several African countries. The technology has been disseminated in a variety of ways, including subsidies and supplies of raw materials. Larger biogas plants for community and industrial purposes have been built in some of these countries.

(d) Information flows

96. Information on biomass energy is available in diverse forms - computerized databases, abstracting journals, energy information abstracts, magazines, reports, satellite networks etc. Utilization of available information by developing countries has been hampered by lack of adequate retrieval systems. Database facilities are mostly located in developed countries, and effective linkages are yet to be developed. Because of the limited distribution of such publications as progress reports, evaluation reports, and technical papers from international organizations, information has often failed to reach the right quarters.

(e) Education and training

97. China, India, Indonesia, Kenya, and Thailand have included programmes on bioenergy, including biomass, in the curriculums of schools and colleges. To educate the public and policy makers on the role and relevance of bioenergy, exhibitions, posters, competitions, essay writing and school projects have been used in several countries. In some countries, bioenergy societies have been established.

98. At the national level, training programmes in bioenergy have focused on biogas construction personnel, maintenance technicians and persons involved with improved wood stoves, especially women. The subject-matter also covers biomass plantations and storage, charcoal-making, and the operation of gasifiers. In countries like Brazil, with a large national programme on ethanol, training is well institutionalized. In a few other countries, separate training centres have been established to train professionals.

4. Fuelwood and charcoal

(a) Assessment and planning

99. The wood energy situation is better understood today, thanks to information and statistics gathered over the past 10 years. The main protagonists of wood energy systems, on the sides of both supply and demand, are clearly identified, and their roles are better defined than in the past. In addition, forest resources are beginning to be assessed and evaluated in a more systematic way.

100. At the beginning of the 1980s, during the "oil crisis", the use of woodfuels by poor people was seen as the cause of deforestation and desertification. It is now recognized that other factors such as farming, forest fires, the industrial use of forests etc. are the chief causes of the deforestation process and that very often woodfuels are only a by-product of land clearance operations. Wood energy activities carried out in isolation, without the proper adjustment of energy or forestry institutions, may not, therefore, be sufficient to tackle the problem of forest destruction.

101. Unfortunately, the quality of the figures and data available for woodfuel production and consumption is inadequate for the preparation of a detailed sectoral review. This lack of accurate information leads to controversial interpretations of the energy situation in developing countries and hampers the correct identification of solutions.

102. Considerable progress has been achieved in creating national capabilities, and most of the activities undertaken have been focused on strengthening research, training, education and woodfuel surveys. However, additional efforts are required to create multidisciplinary groups capable of mastering the subject and to incorporate the active participation of non-governmental organizations into the planning and implementation of wood energy projects. Unfortunately, energy policies and planning have usually not taken due consideration of fuelwood and charcoal.

(b) Research, development and demonstration

103. Research on high-yield species and more productive wood energy plantations, using indigenous and exotic species, has received a great amount of attention, and today, there is a considerable amount of experience and information in this area of work. Efficient cooking stoves for household use and improved techniques for making charcoal have also been given considerable attention.

104. Activities aimed at developing the use of producer gas as engine fuel for power and electricity generation in rural communities, the use of ligno-cellulose residues, and briquette and pellet production are now, from a technical point of view, well developed. However, the wide dissemination of these technologies is considerably affected by the present low price of fossil fuels.

105. Very little research has been done on the utilization of woodfuels for thermal energy in cottage, medium and large-scale industries and enterprises. It has been realized that the use of woodfuels in the industrial, commercial and public sectors of developing countries requires study, owing to its economic (income generation) and social (job creation) implications in rural areas.

(c) Transfer, adaptation and application of mature technologies

106. Activities on tree plantations using extension, agroforestry and community forestry schemes received great support during the 1980s. But the management of existing forests as suggested in the Nairobi Programme of Action has not received all the assistance required. The experience gained in this field, particularly with agroforestry and community forestry, is relevant and very important for the implementation of future activities.

107. The distribution of improved cooking stoves and charcoal production techniques has received a great deal of support. Unfortunately, the results have not met expectations, and new approaches to the work in this field have to be developed. Activities on the health and environmental aspects of using woodfuel in households should be given more attention.

(d) Information flows

108. This area received considerable support in the first half of the 1980s but less in the second half. Even though a good number of bulletins, newsletters and cooperative networks have been established, it still offers great potential for development.

(e) Education and training

109. Many people from developed and developing countries have taken part in a wide variety of meetings and training activities, not all of which have received the required follow-up. A number of the activities have, however,

created a critical mass of experts able to deal with wood energy matters. It is an area which deserves more attention.

5. Hydropower

(a) Assessment and planning

110. In the past 10 years, hydropower has been fully recognized as an essential component of sustainable energy strategies. Compared with all new and renewable sources of energy, from commercial and non-commercial sources, hydropower takes second place only to biomass, and in terms of energy output, it takes first place.

111. Less than half (40.9 per cent) of the hydro resources world wide are considered exploitable. Of those, only an estimated 16.6 per cent, or 2,094 Terra Watt hours (TWh), had been exploited by 1989. The total net exploitable amount is estimated at 12,600 TWh world wide - 5,160, or 41 per cent, for developed countries and 7,440, or 59 per cent, for the developing countries. However, only 712 TWh had been exploited in the developing countries by 1989 - in other words, only 9.6 per cent of the total capacity. In the developed countries, 1,382 TWh, or 26.8 per cent, had been exploited by 1989.

112. The average increase in world energy production from hydro plants during the period 1980-1989 was 19.3 per cent - 6.9 per cent in the developed countries and 54.1 per cent in developing countries. The large percentage rise in the developing countries can be explained by the much lower power generation level from which the rise occurred. Thus the capacity additions during the same period were 73.2 gW for developed countries and 76.6 gW for the developing countries.

113. Hydro plant utilization rates for large hydro plants decreased after 1980 in the developed countries by 11.5 per cent because of the greater emphasis on load-following and momentary system control. In the developing countries the decrease was 7.8 per cent, in part because of output restrictions suffered by some of the major installations - e.g., Cohora Bassa in Mozambique and Inga in Zaire.

114. Many countries have not yet fully surveyed their small-scale hydro potential. In its most recent survey (1989) the World Energy Council estimates a potential of 813 Terra Watt hours (TWh) (6.5 per cent of the total potential), of which 11 per cent had been exploited up to 1989. The total capacity of mini/micro schemes rated below 1mw is 9.25 gW world wide; this is equivalent to 1.5 per cent of the total installed hydro capacity. An equal amount of small-scale plant capacity is currently in the planning stage.

115. Inventories of suitable hydropower sites have been established for many areas, and a vast catalogue of exploitable sites is available. The inventories are updated with new hydrological information. Many of the best sites have already been exploited, particularly in the industrialized

countries where sites are conveniently close to demand centres. However, only a fraction of the sites that are already known have been developed. There is still lack of knowledge on the potential of small sites in outlying areas and a need for additional surveys.

116. It has become the usual practice with larger hydro developments to carry out pre-feasibility studies. The critical parameter in these studies is the hydrology of any given development. The previous rules-of-thumb method can now be replaced by computerized correlation studies of hydro-meteorological data, but an entirely reliable result against any possible climatic cycles cannot be guaranteed. However, any unforseeable risks can to some extent be reduced by flexibility in design.

(b) Research, development and demonstration

117. Hydropower is a mature technology and does not require extensive research and development in a general way. There is continual research on the manufacturing side covering the application of new materials, designs and procedures. Such work is limited to those developing countries with a sufficiently large manufacturing base and an adequate market for their products - e.g., China and India.

118. Demonstration schemes in small hydropower are sponsored by a number of agencies, not because innovative technologies are involved but rather to offer experience and practical training and to test the value of hydro development in rural and remote locations.

(c) Transfer, adaptation and application of mature technologies

119. Unlike other non-traditional forms of new and renewable sources of energy, the basic hydropower technology has not changed materially since the concept was first put in practice 100 years ago. Experience and modernization have, however, led to considerable progress in design so as to improve the efficiency of water utilization, the economy of construction and the reliability and safety of operation.

120. The two most significant technological improvements involve placing civil engineering works underground and the utilizing very low heads of water. Advances in tunnelling methods have reduced the costs of rock drilling and excavation and made it possible to leave quite large excavated volumes underground unsupported and completely safe. The utilization of low heads has been made possible by the development of new turbines; the best known are the bulb turbines. New designs for low-head applications are still being developed, the incentive being better utilization of river flows and also tidal and wave power, which involve very low heads. Bulb turbines and similar machines are suitable for power schemes down to perhaps 2MW or 3MW, but they do not yet play a role in very small schemes. Technology transfer has enabled developing countries to take advantage of these technological advances, and several projects have adapted to these new methods.

121. In terms of technology transfer, only a few developing countries participate to any major degree in hydropower development in their own countries. There are still problems with the operation and maintenance of the plants installed and with their subsequent deterioration. Another common problem is that power plants are built far from their design and manufacturing base. There is therefore much call for the application of intermediate technology, particularly in decentralized situations.

(d) Education and training

122. Programmes have been funded, as part of multilateral agency support, by UNDP, regular United Nations programmes, and agency budgets supported by bilateral contributions. In the 1980s roughly 10 per cent of UNDP expenditure in the hydropower sector was spent on training, most of the projects being executed by the Department of Technical Cooperation for Development. The expenditure on training is expected to rise to nearly 50 per cent of the hydropower budget for the period 1991-1995; this increase is due to relatively large pipeline projects in Bangladesh, India, Laos and Viet Nam and does not amount to any basic change in funding policy.

123. Various training programmes were undertaken in recent years, including secondments for professional-grade personnel; courses at universities (e.g., the University of Rorkee, India, for Nepalese engineers); establishing training programmes and centres in developing centres (e.g., Bangladesh, India and Laos); on-the-job training for both supervisory and technical staff (e.g., Bhutan, Ethiopia, Ghana, Thailand and Viet Nam) and seminars and workshops in Jordan, Norway and Sweden.

124. Bilateral agency support projects tended to be more closely aligned with the particular developments that the agencies were supporting - for example, German projects in Indonesia and Pakistan. The aim of these activities was to build up a strong and competent counterpart organization.

125. With regard to the support of non-governmental organizations, the journal Water Power and Dam Construction has been instrumental in organizing four conferences on small-scale hydropower. Organizations such as the World Energy Council hold regular conferences every three years, and the International Conference on Large Dams holds a number of international meetings.

126. The Hangzhou Regional Training Centre has become an important focal point for the Asia/Pacific regional network. A network organized by OLADE has been in operation in Latin America for some years. There are now plans to set up a similar network in Africa. Discussions on this initiative of the ECA are under way.

6. Geothermal energy

(a) Assessment and planning

127. An assessment and quantification of geothermal energy resources in terms of megawatts can be made only after a geothermal exploration project and a feasibility study have been carried out. Initial exercises for the assessment of geothermal energy resources can only give a qualitative picture.

128. Geothermal activity is controlled by regional and local geology. Plate tectonics has provided the basis for planning the exploration of geothermal energy resources. Its development and use depends on various factors: the nature of the heat source, the depth of the source, characteristics of the reservoir, the cap rock, and the possibility of recharge etc. These factors determine the nature of the resource and its suitability for low-, medium- and high-temperature uses.

129. From an analysis of plate tectonics, high-temperature geothermal resources suitable for exploration for large-scale electricity generation are likely to exist are in Argentina, Bolivia, Chile, Colombia, Costa Rica, Djibouti, Ecuador, El Salvador, Ethiopia, Guatemala, Iceland, Indonesia, Italy, Japan, Kenya, Mexico, New Zealand, Nicaragua, Panama, Papua New Guinea, Peru, the Philippines, Turkey, Uganda, United Republic of Tanzania, United States, USSR, and Venezuela. In some of those countries, the resources have been proven and in some cases are currently under exploitation for both electricity generation and direct application.

130. Countries where geothermal resources for small- and medium-scale power generation may exist are Burundi, Cameroon, Canada, Cape Verde, Chad, China, Democratic Republic of Korea, Dominica, France (Guadeloupe and Martinique), Greece, Grenada, Honduras, India, Iran, Madagascar, Malawi, Malaysia, Mongolia, Mozambique, Myanmar, Pakistan, Portugal (Azores), Republic of Korea, Romania, Rwanda, St. Kitts and Nevis, St. Lucia, St. Vincent and the Grenadines, Samoa, Solomon Islands, Spain/Canary Islands, Sudan, Thailand, Vanuatu, Viet Nam, Yemen, Zaire, Zambia and Zimbabwe. The potential for direct application is much higher than power generation in those countries.

131. Progress has been made at the national level by some countries in the exploration and application of geothermal resources.

(b) Research, development and demonstration

132. Geothermal energy technology is already mature and is already utilized on a significant scale. Research and development activities are being undertaken to achieve further progress on geoscientific and engineering aspects. These activities have contributed to improving geothermal resource exploration and production. Research and development activities are of a multidisciplinary nature, involving geological, geochemical and geophysical methods; hydrogeology; volcanology; petrology; hydrothermal mineralogy; slim hole drilling; deep, large-diameter drilling; well logging and testing; reservoir

engineering; corrosion studies etc. These activities require facilities and trained workers. Developing countries require assistance in developing capabilities for acquiring and adapting technologies suited to specific country situations.

(c) Transfer, adaptation and application of mature technologies

133. The Organizacion Latinoamericana de Energia (OLADE) has developed methods and guidelines for geothermal exploration and development which are useful for developing countries. They have been used by countries in Latin America, Asia and Africa, especially in geothermal projects supported by the United Nations system.

134. During the past 15 years the utilization of geothermal energy for electricity generation has increased significantly. The total installed geothermal power capacity in the world increased from about 1,278 MW in 1975 to about 5,875.6 MW in 1990. Moreover, the gap in installed capacity of geothermal energy between the industrialized and the developing countries has narrowed significantly. In 1975 the total installed capacity in the developing countries was about 10 per cent of that of the industrialized countries - 123 MW versus 1,155 MW. In 1980 it was about 41 per cent - 725 MW vs. 1,752 MW; in 1985 about 35 per cent - 1,559 MW vs. 2,342 MW; and in 1990 the ratio was about 50 per cent - 1,955 MW vs. 3,920 MW.

135. However, it should be noted that 81 per cent of the present geothermal power capacity in developing countries (1,955 MW) is installed in only two of those countries, Mexico and the Philippines, with El Salvador and Indonesia accounting for about 12 per cent. The remaining 7 per cent of the total installed capacity is in eight other developing countries - Argentina, China, Kenya, Nicaragua, Thailand, Turkey and Zambia. There is similar disparity in the industrialized countries, where 70 per cent of the installed capacity (3,920 MW) is installed in the United States and 28 per cent in Italy, Japan and New Zealand; the remaining 2 per cent is in France (Guadaloupe), Greece, Iceland, Portugal (Azores) and the USSR.

(d) Information flows

136. The flow of information on geothermal energy has been spurred by the past conferences and workshops on the subject. Technical papers on geothermal exploration, development and utilization are being published in two monthly journals - Geothermics and Geothermal Resource Council Bulletin, both of which are distributed world wide. The International Geothermal Association, established a few years ago, contributes to the flow of information. Other notable bodies which have become a source of information are the Geothermal Technology Division of the United States Department of Energy and the Geothermal Energy Commission. New Zealand's annual geothermal workshop (now in its twelfth year), the Geothermal Energy Programme of EEC, and the geothermal workshops organized every five years by ECE also contribute to the flow of information.

(e) Education and training

137. China, Indonesia and the Philippines have used their mining and geological survey institutions for training personnel. They and other countries have availed themselves of education and training facilities offered by the following international geothermal training centres:

(a) International School of Geothermics at Pisa (Italy): 258 students from 56 developing countries have graduated since 1970;

(b) United Nations University's Geothermal Energy Training Programme at Reykjavik (Iceland): 93 students from 20 developing countries since 1979;

(c) Geothermal Institute of the University of Auckland, (New Zealand): 279 students from 27 developing countries since 1979.

Japan has also provided training at Kyushu to a number of students from developing countries.

138. Short-term training courses have been organized in the above-mentioned institutions for personnel sponsored by UNDP, and on-the-job training has been provided by experts from geothermal projects executed by the Department of Technical Cooperation for Development in China, Indonesia, Kenya and the Philippines.

7. Draught animal power

(a) Assessment and planning

139. Basic data has been collected on the distribution of species, breeds, draught capabilities, the effect of energy on crop yields, agricultural implements, harnessing devices and existing draught animal power technologies. Consideration of Animal power as a basic energy input in agriculture planning has been considered.

140. Animal traction is currently receiving considerable attention in many countries in Africa and Asia, with Governments, international and bilateral agencies, national and international research centres, universities and non-governmental organizations redirecting their agricultural policies towards greater focus on small-scale farmers and their needs.

141. There has been a slow but gradual change over the past 10 years in the attitudes of policy makers, scientists, extension and training personnel and others involved in agricultural development concerning the present and potential role of animal traction in farming systems. The major reasons for the increased interest in draught animal power are the high cost of imported machinery, the foreign exchange burden of purchasing fossil fuels and the disappointing results of introducing tractors, particularly in Africa, for achieving projected increases in agricultural production.

142. The direction of national policies relating to the use of draught animal power in many countries is poorly defined, and this has severely hampered research planning. Frequently, different ministries are responsible for livestock, agricultural engineering, agronomy and socio-economic development, and they may, in turn, be subdivided into several departments, making it difficult to charge a single authority with establishing and coordinating draught animal power research activities. Cooperation, liaison and information exchange between external donor agencies, non-governmental organizations and international centres involved in the research and development of animal traction in sub-Saharan Africa have been minimal.

(b) Research, development and demonstration

143. Research and development activities have been undertaken in the design, development, testing and evaluation of agricultural implements, animal-drawn vehicles, harnesses and hitching devices so as to enhance the productivity of draught animals. Appropriate breeding schemes, draught animal feeding and management, fodder and the improvement of pastures have also been studied.

144. The volume of research literature on draught animal power is relatively small, compared with that on animal production or on other types of agricultural traction. Most of the information on animal traction in sub-Saharan Africa focuses on historical reviews and case studies, implement design and testing, and socio-economics, with much less documentation available on the management, nutrition and working performance of draught animals. In Asia, research has been concentrated in two main areas - the economics of using draught animals compared to tractors, and the design and testing of implements. A substantial number of studies has also been carried out in India to determine the effects of work on various physiological indices of stress in cattle and buffalo.

145. However, over the past few years, recognition of the important role that draught animals play in agricultural systems and of the potential for increasing or improving the use of draught animal power technology among smallholders has resulted in the formation of national animal traction programmes in several African countries. They are now using multidisciplinary teams to carry out research, training and development.

146. The piecemeal nature of the research effort on draught animal power is disturbing. Animal traction research has often been carried out without a clear understanding of the biological and socio-economic constraints facing farmers in different agricultural systems. Preliminary efforts to determine whether the introduction or expanded use of draught animal power would be profitable or to identify factors which might limit its adoption or growth have frequently been omitted. In Asia, too, there has been a lack of coordination between livestock and mechanization programmes.

(c) Transfer, adaptation and application of mature technologies

147. One goal of the Nairobi Programme of Action is for the energy needs of rural areas to be met on a sustainable basis. To that end priority action for transferring, adapting and applying improved techniques for utilizing draught animal power, including improved husbandry practices, are being promoted. Measures should be taken to support ongoing draught animal programmes in developing countries.

(d) Education and training/information flows

148. The important contribution of draught animal power to small-holder agriculture can be seen in the number of recent meetings, conferences and workshops which have been held in Africa, Asia and Australia for the purpose of exchanging information on the use of draught animals and the need for research and development. There has also been recent interest in the establishment of networks relating to animal traction research, training and development activities in sub-Saharan Africa and in Asia and the Pacific. Such networks would foster a clearer focus on research and development efforts, act as a vehicle for the exchange and dissemination of information, and provide opportunities for training. Newsletters devoted specifically to various aspects of management and research on draught animals are currently being published.

8. Ocean energy

(a) Assessment and planning

149. There has been little additional data on the extent of ocean energy resources in the past 10 years. A local assessment is usually made if a feasibility study for a particular site is being considered. Since interest in ocean-energy technologies has not matched the expectations at the Nairobi Conference, little specific policy formulation or planning regarding them has been made. In island developing countries, where many of the technologies would be most suitable, energy policies are oriented towards conventional energy sources, since the cost of conversion to ocean energy is still not competitive.

(b) Research, development and demonstration

150. For open-cycle ocean thermal energy conversion systems, certain hurdles and challenges still exist, since less research effort has been devoted to them than to closed-cycle systems. The open-cycle system requires much larger turbines and vacuum chambers because of the low-density steam used. The oversized equipment needs more operational testing. Some positive results have, however, been achieved, in the development of the evaporators, condensers and turbines essential to open-cycle systems, such as vertical-spout evaporators and direct-contact condensers. Work has also been done on direct-contact heat exchangers which are usually more efficient than surface condensers and yield higher power outputs. If desalinated water is

also required, large surface condensers have to be used. The use of aluminium for the heat exchangers, together with regular chlorination, has reduced costs considerably. There are vast problems associated with building long cold-water pipes with large diameters which can withstand deployment to 1,000 metres in depth. Pipe materials such as concrete, steel, fiberglass-reinforced plastic, elastomers and composites are being studied.

151. Different wave-power concepts have been tested. However, only two have actually gone into medium-size demonstration: the Multi-resonant Oscillating Water Column system and the Tapered Channel Wave Power Plant system, both developed in Norway. These systems are expected to receive further attention. There are indications that the interest in government-funded research on wave power has revived - for example, in the United Kingdom. The Government of Japan is still active but moving slowly. The Government of the United States has no funds for wave technology. The modular nature of wave power technology could prove advantageous for developing countries because it would lower capital costs.

152. Applications of tidal power use are based mainly on mature and demonstrated technology whose use is limited by such factors as environmental impacts, high capital costs, and a limited number of suitable sites.

153. In 1984 the Commission of the European Communities prepared studies on wave and tidal power, ocean energy thermal conversion and offshore wind energy. In 1988, it initiated a programme for marine science and technology, including new and renewable sources of energy, worth 50 million European currency units (ECU). Within the United Nations system, UNDP did a pre-feasibility study on the utilization of wave energy for Cape Verde.

(c) Transfer, adaptation and application of mature technologies

154. In 1984, the Department for International Economic and Social Affairs of the United Nations Secretariat produced a document called "Guide to ocean thermal energy conversion for developing countries", aimed at enhancing the transfer and adaptation of this technology. However, in the energy price climate of the past 10 years, financing has not been forthcoming.

155. Three developing countries - India, Indonesia and Jamaica - were identified as having a well-developed infrastructure for marine science and coastal area development and a viable energy planning strategy. Most other countries have limited capabilities to undertake or participate in the technical aspects of ocean energy assessment. The legal framework can become quite complicated, because it involves the deployment of structures on the high seas. The lack of a clear statement as to whether or not the deployment of energy-producing structures such as wave-power plants or ocean thermal energy conversion plants are legal under national and international law, the lack of laws or regulations ensuring continuing access to ocean energy resources by a particular plant, the lack of clarity on the application of laws covering conventional power plants to land- or offshore-based ocean energy plants - these would have to be addressed and resolved before a country or company would risk deployment of a commercial plant.

(d) Information flows/Education and training

156. Information is exchanged mainly through academic channels such as the large technical and scientific databases and libraries. Various professional organizations such as the American Society of Civil Engineers either organize meetings dedicated to ocean energy or discuss ocean energy at meetings on hydropower and renewable energy in general. Education and training, when given, is mostly at the university level, mainly for engineers. Major efforts will have to be made to offer training at lower levels, to technicians and maintenance workers, if these technologies are to be efficiently utilized in developing countries. The Department of Technical Cooperation for Development of the United Nations Secretariat has been involved in training. In India in the area of power technology (including tidal power), it has awarded several fellowships. The Economic and Social Commission for Asia and the Pacific included ocean energy in a workshop held in conjunction with the Asian Energy Power 1987 Conference, held in Malaysia.

9. Tar sands

(a) Assessment and planning

157. The locations of large accumulations of tar sands have been determined, but the quantities in place are not accurately known.

158. Many of the tar sand deposits in developing countries are small and in remote localities which make exploitation difficult or, at the very best, expensive. Seventy-five per cent of the world's tar sands are located in Western Canada, 22 per cent in the USSR and the remaining 3 per cent is distributed among 18 other countries; 99 per cent are concentrated in a few giant deposits.

(b) Research, development and demonstration

159. China, Jordan, Trinidad and Tobago and Venezuela are the only developing countries in which evaluations of tar sand deposits have been carried out. Venezuela exploits tar sands commercially and has developed a bitumen emulsion process, orimulsion, which has been successfully tested as a substitute for coal in thermoelectric power plants.

(c) Transfer, adaptation and application of mature technologies

160. Canada is the only country where energy fuel from tar sands has been commercially produced. The Canadian oil sands industry has reached an advanced stage of maturity, and the Alberta Oil Sands Technology and Research Authority conducts international cooperative programmes, ranging from resource evaluation to bitumen upgrading. The Authority has joint programmes with Brazil, China, Jordan, Trinidad and Tobago and Venezuela.

(d) Information flows

161. The UNITAR/UNDP International Conferences on Heavy Crude and Tar Sands, and the UNITAR/UNDP Information Centre for Heavy Crude and Tar Sands are information sources within the United Nations system. The Alberta Oil Sands Technology and Research Authority publishes an on-line bibliographical database dealing exclusively with tar sands.

10. Oil shale

(a) Assessment and planning

162. Oil shale deposits are known to occur in more than 38 countries, and oil shale industries have existed in some of those countries at one time or another. At the present time oil shale is being utilized only in China and the USSR. In the United States, a single oil shale plant which operated with subsidies for a few years has been closed down. A pilot plant has been in operation in Brazil for many years. Evaluations of oil shale deposits for development potential have been conducted in India, Jordan, Morocco and Thailand.

163. Only very rough estimates of the grade and quantity of the oil shale deposits in the developing countries are available. Detailed investigations are necessary if economic evaluations are to be made.

(b) Research, development and demonstration

164. Project developments are continuing in Brazil, China, India, Jordan, Morocco and Thailand.

(c) Transfer, adaptation and application of mature technologies

165. Demonstrated technology exists for the mining and retorting of oil shale, but the economics of its development remain very uncertain, with many estimates indicating a price of over $50 per barrel of oil equivalent. No comparable estimates of the cost of electricity based on oil shale are available, although it is known that two electric power stations of a combined capacity of about 3,000 MW are in operation in Estonia.

(d) Information flows

166. International conferences on oil shale and shale oil are held every few years. Numerous publications on all aspects of oil shale development and shale oil production are available.

11. Peat

(a) Assessment and planning

167. The total amount of fuel peat resources has been estimated at 22×10^9 tons of coal equivalent. At least 40 countries are known to have peat. The The principal users are the USSR, Finland and Ireland. Precise statistics on current peat production are unavailable; however, it appears that the exploitation of peat has decreased in the last few years.

168. There is no large-scale commercial peat production in the developing countries. However, studies have been carried out in Brazil, Burundi, Indonesia, Jamaica, Senegal and Sri Lanka. They have shown that production is technically practicable with the machinery used in developed countries. For large-scale production some modifications would have to be made, owing to the different properties of the fuel.

(b) Research, development and demonstration

169. Research is being undertaken in the artificial dewatering, gasification and liquefaction of peat. Several non-conventional techniques are receiving more attention by researchers. These "wet" methods (artificial processing) are being developed in order to minimize the effect of climatic conditions and to prolong the production season. Finland has two comprehensive research programmes concerning peat production. In Sweden a research and development programme produces briquettes with wet methods, and the briquettes are used for district heating in Uppsala.

(c) Transfer, adaptation and application of mature technologies

170. Peat technology is well established for conventional peat production and use but might have to be adjusted to local conditions. In many countries it has recently been shown that near consumption sites, fuel peat provides cheap local fuel. Peat offers a viable alternative to scarce fuelwood for home cooking in developing countries and can replace imported fuels in generating heat, electricity or power for industrial use.

171. In tropical developing countries the production of both milled and sod peat has been studied. Projects have shown that peat can be produced technically and commercially. The projects have also provided valuable information on the properties of tropical peat.

172. At the International Peat Society Tropical Peat Symposium, held in Indonesia in 1987, a proposal was made to establish a tropical peat centre. The centre would promote and conduct research and technology transfer in the tropics. Some progress has been made to this end, but more international collaboration is needed in order to realize the programme.

(d) Education and training

173. The utilization of peat requires much specialized knowledge - e.g., quality of peat and peat lands, climate effects and demands on peat production, and environmental factors that are not directly included in regular educational programmes. Personnel training must be coordinated with other practical measures for the realization of development programmes. Most critical is the training of technical personnel to evaluate the peat resources and planning of peat production. International cooperation and participation in conferences and seminars are essential.

(e) Information flows

174. The utilization of peat is interdisciplinary in character. Information is therefore sought from many different sources (agriculture, forestry, energy, transportation etc). Peat publications in international databases exist, and they are added to at the rate of 200 a year.

175. There is no abstract journal or database with international coverage of the whole field. However, OECD/IEA is starting an information system covering biomass energy which will include peat, and the journal of the International Peat Society is published yearly. Distribution is limited, and many of the articles are published in Finnish, German, Russian or Swedish.

IV. FACTORS BEARING ON THE IMPLEMENTATION OF THE NAIROBI PROGRAMME OF ACTION

A. Policy factors

176. In any given country, many factors bear upon policy formation with regard to new and renewable sources of energy: the exploitation and utilization of new and renewable sources of energy vis-à-vis other sources of energy; national resource endowments; the physical and geographical setting; the organization of agriculture and industry and other relevant sectors; the state of urbanization and socio-economic development; and the impact of changes in the international energy markets. The type, size and scope of programmes, projects and activities undertaken by the country and by the United Nations system and other multilateral agencies are also affected.

177. The policy environment during the latter part of the 1980s was unfavourable to the promotion of new and renewable sources of energy, largely due to favourable conditions in the international oil markets. Energy issues which had brought the international community to the Conference on New and Renewable Sources of Energy at Nairobi receded into the background, and energy policy became a short-term exercise. The need for the longer-term approach emphasized in the Nairobi Programme of Action tended to be overlooked. Although countries acknowledged the need for greater reliance on new and renewable sources of energy in order to achieve a better energy mix,

corresponding action to adopt appropriate policies at the national level was not taken, and no attempt was made to integrate new and renewable sources of energy into national energy policies and plans. By contrast, energy conservation policies and actions have been vigorously pursued, especially in developed countries. In fact, energy conservation became the focus of attention in those countries during the 1980s, and yielded remarkable results. But energy conservation alone has not been and will not be sufficient.

178. Energy pricing policies have had an important bearing on the implementation of the Nairobi Programme of Action. Policies that do not take full account of all relevant costs place new and renewable sources of energy at a disadvantage. However, if conventional energy and renewable energy are compared in terms of all the relevant costs including not only production and distribution but also environmental and social impacts - many new and renewable sources of energy technologies would prove to be economically attractive, even at the current levels of cost and of development. It is only in recent years that such external costs have begun to be recognized, and their incorporation in cost calculations may tilt policies in favour of expanded use of new and renewable sources of energy technologies in the future. So far, policies for encouraging private-sector investment in new and renewable sources of energy projects have been ineffective, owing to inadequate incentives and, in the case of producers, individual users and manufacturers of new and renewable sources of energy equipment, inadequate access to credit facilities or lease finance.

179. Rural energy has been identified as an area requiring priority action. The vast majority of people who live in rural areas have severe energy problems. Yet not much effort has been made to solve them. Only the fuelwood problem has received some attention. On the whole the role that new and renewable sources of energy could play in decentralized development has been overlooked in energy policy. It should be noted that the role of new and renewable sources of energy in meeting energy needs in rural areas has hardly changed, even during the current period of low oil prices, since most of the rural population in developing countries have very little access to hydrocarbon fuels.

180. In the past two years, however, the attitude towards policy seems to have changed, largely due to increasing concern about the environmental, social and economic consequences of the continued exploitation and use of fossil energy. The threat of global warming and global concern for sustainable energy development have rekindled interest in the development and utilization of new and renewable sources of energy and, therefore, the adoption of appropriate policies may have a strong bearing on the implementation of the Nairobi Programme of Action.

B. Institutional factors

181. At the national level, although as many as 120 countries have established national focal points for new and renewable sources of energy, their roles have been limited, except in countries like Brazil, China, Egypt and India.

182. The institutional arrangements in China and India are particularly extensive and effective. In China, a separate wing under the State Committee for Science and Technology is responsible for new and renewable sources of energy. A variety of institutional structures have been established for individual energy sources such as biogas, hydropower, solar energy, geothermal energy etc. at various levels. Likewise in India, a separate high-powered commission called the Commission for Additional Sources of Energy has been established for policy guidance. A separate government department under the Ministry of Energy takes responsibility for the planning and implementation of programmes and projects. A national centre on solar energy and several subject-specific centres have been established. There also exists a separate financing body for financing new and renewable sources of energy projects on concessional terms. These types of institutional arrangements at the national level and their links with extension machinery have been helpful in the mounting of major national programmes. They are needed for promoting the large-scale application of new and renewable sources of energy. Many developing countries lack apex-level and downstream institutions of the type that have been established in China and India. That is one reason why achieving the objectives of the Nairobi Programme of Action has been slowed down.

1. United Nations initiatives

183. The Committee on the Development and Utilization of New and Renewable Sources of Energy, established by the General Assembly, is entrusted with a number of functions - inter alia, to recommend policy guidelines for the entities within the United Nations system in regard to new and renewable sources of energy, and to formulate and recommend action-oriented plans and programmes for carrying out the Nairobi Programme of Action. The Committee on New and Renewable Sources of Energy is open to participation of all States. Its report, containing conclusions, decisions and recommendation, is submitted to the General Assembly through the Economic and Social Council. The decisions and resolutions of the General Assembly on the report of the Committee provide the basis for follow-up by the organs, organizations and bodies of United Nations system and for appropriate action by Governments and the international community.

184. At its third session (1986) the Committee decided to adopt a substance-oriented approach that would enable it, at each of its sessions, to give depth to its deliberations by concentrating on one or two themes. Delegations have welcomed the new approach.

185. In 1982, in resolution 37/250, the General Assembly decided to establish secretariat arrangements for coordination functions and support services for the Committee on the Development and Utilization of New and Renewable Sources of Energy. The support arrangements have been implemented in the Office of the Director-General for Development and International Economic Cooperation, through the appointment of a special coordinator, and in the Department of International Economic and Social Affairs through the establishment of a Section on New and Renewable Sources of Energy. Other units within the system, including the United Nations regional commissions, UNDP, various specialized agencies and the World Bank are involved in activities on new and renewable sources of energy.

186. In 1982, various entities of the United Nations system initiated projects and programmes as part of the implementation of the Nairobi Programme of Action. The progress achieved has varied. Many of the entities have stated that a scarcity of resources - financial, human and equipment - has had a negative impact on the extent of their activities in the field of new and renewable sources of energy. The available resources are inadequate for any serious implementation of the many projects that would have to be undertaken in order to have the necessary impact. Some of the entities have indicated a lack of travel resources necessary for missions, consultations and the exchange of valuable experience and information.

C. Inter-agency coordination

187. The General Assembly, in resolution 37/250, decided to establish the ACC Inter-agency Group on New and Renewable Sources of Energy. The Group would, inter alia, facilitate coordination of activities within the United Nations system for the purpose of avoiding duplication of effort, eliminating bottlenecks in the implementation of the Nairobi Programme of Action and fostering cooperation among the different entities in the United Nations system on a continuing basis. The ACC Inter-agency Group would also monitor and coordinate information on activities outside the United Nations system, including, in particular, those on bilateral cooperation.

188. The Inter-agency Group has held 10 sessions, at which representatives of the different member entities have exchanged information on their experiences and implementation of specific projects in the field of new and renewable sources of energy. The sessions have provided an opportunity for the representatives to respond to the decisions of the Committee and the General Assembly regarding implementation of the Nairobi Programme of Action.

189. The importance of coordinating the activities of the United Nations system in the field of new and renewable sources of energy has been underlined by the Committee. The Committee has, however, felt that there is scope for further improvement.

D. Financial factors

190. The Conference of New and Renewable Sources of Energy recognized that the implementation of its Programme of Action would require the mobilization of additional and adequate resources, and there was clear understanding that the magnitude of financial needs would be very significant. While each country would bear major responsibility for the development of its own new and renewable sources of energy programme, the developing countries would require international financial support for their national efforts, both public and private, from all developed countries, international financial institutions, other international organizations, and also from developing countries in a position to provide assistance.

1. Financial requirements

191. The financial requirements for implementing the Nairobi Programme of Action were of various types - from supporting actions and pre-investment activities to investments in individual projects. No fixed target was established for these requirements in developing countries, and there were reservations on the part of a number of participants in the Conference about fixing such targets, particularly in view of great uncertainties involved in the underlying assumptions for development and utilization of new and renewable sources of energy. However, as a starting point, the World Bank and UNDP were invited to undertake a joint study for estimating the financial needs for supporting actions and pre-investment activities in developing countries.

192. The study came up with the very rough amount of $14.2 billion, plus or minus 15 per cent, for the period 1982-1990 at 1982 prices, 4/ as shown in table 7. Of this amount 72 per cent was for hydropower and geothermal energy, and the balance of 28 per cent for other new and renewable sources of energy. It had been calculated that, with the expansion of absorptive capacity for implementation of new and renewable sources of energy projects in developing countries, the rate of expenditure would increase from about 28 per cent of this amount during the first four years to 72 per cent in the following five years. Moreover, the foreign exchange share of these requirements was estimated to be around 45 per cent, to be financed mainly through international assistance and support.

193. The breakdown of these financial requirements (table 7), shows that supporting actions were estimated to absorb one quarter of the total, in such areas as energy planning and assessment; research, development and demonstration; and training and education. The remaining three quarters was for pre-investment activities covering feasibility studies and the design and engineering works - most of them for hydropower.

194. With respect to the total investment requirements in the energy sector, including both conventional energy and new and renewable sources of energy, in developing countries, some rough estimates were made by the Department of International Economic and Social Affairs of the United Nations Secretariat

Table 7. Financial requirements for supporting actions and pre-investment activities for new and renewable sources of energy in developing countries, 1982-1990

(Millions of 1982 United States dollars)

	Hydropower	Other new and renewable sources of energy	All sources
Supporting actions			
Planning and assessment	222	807	1 029
Research, development and demonstration	..	1 462	1 462
Training and education	269	836	1 105
Subtotal	491	3 105	3 596
Pre-investment activities			
Feasibility studies	1 065	558	1 623
Design and engineering	7 652	1 299	8 951
Subtotal	8 717	1 587	10 574
Total	9 208	4 962	14 170

Source: "Financial requirements for supporting actions and pre-investment activities for the development and utilization of new and renewable sources of energy in the developing countries during the 1980s", a joint study by the World Bank and UNDP (A/AC.215/4), April 1982.

and the World Bank in the early 1980s (see table 8). According to the United Nations Secretariat, the requirements amounted to $1,680 billion at 1982 prices, during the period 1982-2000, or a yearly average of about $93 billion. This estimate covered only up-stream investments and did not include the financing required for the development of such operations as electricity generation, oil refining, transportation and marketing. The estimate of the World Bank was somewhat higher, despite the fact that it did not include investments for the development of new sources of energy, although it did take account of investments in nuclear energy.

Table 8. Estimates of energy investment requirements in developing countries

(Billions of 1982 United States dollars)

	World Bank, 1982-1990	United Nations Secretariat, 1982-2000		
		Net energy importers	Net energy exporters	Total
Fossil fuel				
Coal	88.7	53.4	65.7	119.1
Petroleum	465.9	259.6	732.6	992.2
Natural gas	65.4	55.9	91.7	147.6
Subtotal	620.0	368.9	890.0	1 258.9
New and renewable sources				
Hydropower	238.4	260.0	91.0	351.0
Nuclear power	53.2	..	..	..
Geothermal energy	6.5	9.6	3.2	12.8
Other	..	41.5	13.7	55.2
Subtotal	298.1	311.1	107.9	419.0
Total	918.1	680.0	997.9	1 677.9

Source: "Development of the energy resources of developing countries" (E/1983/91 and Corr.1).

195. Of the total investment requirements, about 25 per cent was expected to be the share of new and renewable sources of energy, the bulk of it for hydropower, and only 3.3 per cent was for other new and renewable sources of energy - amounting to an average of $3 billion per annum. The investment expenditures would start from a rather low level and rise along the expansion of absorptive capacity in individual countries. The energy-exporting developing countries were estimated to account for 60 per cent of total investments, mainly in hydrocarbons, and only 25 per cent in new and renewable sources of energy projects. The energy-importing developing countries, on the other hand, were calculated to absorb about 40 per cent of the total investments, but three quarters of new and renewable sources of energy expenditures. Despite such heavy investment requirements, the energy gap of energy-importing developing countries was still expected to continue to increase.

196. Admittedly the mobilization of financial resources of such a magnitude would be a formidable task. The total energy investments for developing primary sources had been estimated to increase, by simple extrapolation, from a level of $25 billion in 1980, to about $70 billion in 1990 and $175 billion in the year 2000. This involved, in energy-deficient developing countries, a substantial expansion of real investment flows to the energy sector from about 1.5-2.0 per cent of their GDP in the late 1970s to an average of approximately 2.5-3.0 per cent over the next two decades. In addition, those countries required additional resources to finance oil imports during the gestation period of the investments and also for the implementation of energy conservation measures.

197. The foreign exchange component of the projected total energy investments in developing countries was estimated to be about one half of the total, to be financed largely by foreign capital inflow. Of course, the share of such foreign costs was expected to differ from one sector or project to another and also from country to country - the requirements being higher in the less developed energy-importing countries. Internal resources would have to finance at least the other half of the energy investment needs in energy-importing developing countries, while in net oil exporters, the ratio of domestic financing would be considerably higher.

198. The energy investment estimates appear to have fallen far short of projected targets, especially in the area of new and renewable sources of energy. In the early years of the decade, in line with the priority given to development of the energy sector, great efforts were made to mobilize domestic and foreign resources for the implementation of new and renewable sources of energy activities. But after 1985, with reduced interest in the energy transition outlined in the Nairobi Programme of Action, investments in new and renewable sources of energy, except in China and India, declined sharply, and most of the related projects were abandoned or slowed down.

199. There are no comprehensive data available on overall expenditures for the development of new and renewable sources of energy programmes and projects, but the existing fragmentary data indicate the low and declining level of such expenditures. For example, as shown in table 9, the public budgets for research, development and demonstration in renewable energies in IEA countries declined sharply, from $1,665 million in 1980 to $487 million in 1990, at 1990 prices - or a fall of about 70 per cent. The decline was more pronounced in the areas of mature technologies (such as solar heating and thermal) and in technologies with little prospect for use in the near future (e.g. ocean energy). Also the share of research, development and demonstration expenditures on new and renewable sources of energy was rather low compared with similar expenditures for other energy sources. The allocation for new and renewable sources of energy was 8 per cent of the total for the energy sector in 1990, having declined from 14 per cent in 1980, as compared with 63 per cent for nuclear energy and 19 per cent for coal.

Table 9. Total research, development and demonstration budgets of IEA countries in the energy sector

(Millions of 1990 United States dollars, unless otherwise specified)

	1980	1990	1990 as percentage of 1980	Percentage of total 1980	Percentage of total 1990
Energy conservation	862.8	388.9	45.1	7.4	6.5
Coal	1 707.6	1 147.1	67.2	14.7	19.3
Oil and gas	477.8	183.3	38.4	4.1	3.1
Nuclear energy	6 981.9	3 745.3	54.3	59.4	62.9
Conventional	(3 499.6)	(2 264.1)	(64.7)	(30.2)	(38.0)
Breeder	(2 369.3)	(654.2)	(27.5)	(20.5)	(11.0)
Fusion	(1 013.0)	(827.0)	(81.6)	(8.7)	(13.9)
New and renewable sources of energy	1 665.4	486.5	29.2	14.4	8.2
Solar heating	(226.5)	(36.6)	(16.2)	(2.0)	(0.6)
Solar thermal	(348.7)	(19.1)	(5.5)	(3.0)	(0.3)
Solar photovoltaic	(330.9)	(177.3)	(53.6)	(2.9)	(3.0)
Wind energy	(164.4)	(85.5)	(52.1)	(1.4)	(1.4)
Ocean energy	(103.7)	(9.1)	(8.8)	(0.9)	(0.2)
Biomass	(136.8)	(66.3)	(48.5)	(1.2)	(1.1)
Geothermal	(354.3)	(69.8)	(19.7)	(3.1)	(1.2)
Total	11 605.5	5 951.1	51.3	100.0	100.0

Source: International Energy Agency.

200. It appears that similar sharp declines have taken place in new and renewable sources of energy expenditures in developing countries, partly due to the keen competition from conventional sources of energy and partly due to severe shortages of capital, from both internal and external sources, for all types of investment programmes and projects. In the light of changing trends in international energy markets during the past several years, the new and renewable sources of energy programmes and projects lost their earlier priority even in areas where they were considered economically and technically feasible. The declines differed by individual country and also by type of activity. In general, despite the considerable efforts made, the financial

resources allocated to new and renewable sources of energy programmes during the past decade was so meagre that they could not make a significant impact on the economies of developing countries, either at the national or at the local levels.

201. The limited availability of funding for the development of new and renewable sources of energy in developing countries, and its sharp decline, were affected by the reduced rate of resource mobilization in most of those countries, resulting from lower rates of domestic savings and also from the drastic declines in external financing. During 1974-1979, the debtor developing countries, which were faced with increasing deficits in the current accounts of their balance of payments, had been able to supplement their domestic savings with an inflow of external resources. In the following few years, the inflow of external resources to developing countries was maintained, but it was increasingly used to meet growing interest payments on foreign debts and to sustain consumption, instead of supplementing domestic savings for internal capital formation.

202. However, after 1982 the financial conditions of these countries worsened greatly as a result of higher interest rates, deterioration in their terms of trade, and inadequate returns from investments to meet their debt-servicing obligations. While the needs of these countries for external financing continued to increase, the availability of such financing decreased, especially in view of the foreign indebtedness of many of them. In addition, with the emergence of the United States of America as the world's largest capital importer, the flow of foreign capital to developing countries fell sharply, necessitating drastic downward adjustments in their economies and investment programmes, including the energy sector.

203. The prospects for external capital inflow to most of developing countries during the 1990s do not appear to have improved, compared with the 1970s although the situation may be somewhat better in relation to the 1980s. It is expected that the declining current account deficits of the United States will release substantial amounts of international financial resources for investments elsewhere. But at the same time it is felt that the requirements of Eastern European countries, the USSR and China, together with the reconstruction needs of war-damaged countries in the Persian Gulf region, will be so great that the pressure on international resources will continue unabated. In these circumstances, the developing countries, in order to continue with a reasonable level of capital formation, must take measures to raise the level of their domestic savings, increase their foreign exchange earnings and, above all, make more efficient use of their scarce foreign exchange resources.

204. According to estimates made by IMF, the domestic savings of developing countries as a whole declined from 26.7 per cent of their GDP during 1975-1982 to 23.7 per cent in 1983-1990. The decline was sharper as regards foreign capital inflow, which decreased from 4.0 per cent of their GDP to 1.8 per cent during the corresponding periods. The changes in foreign capital flow can be noted more clearly by a glance at the current accounts of balance of payments of developing world and some developed countries with large surpluses or deficits.

205. Table 10 shows that the non-fuel-exporting developing countries experienced current accounts deficits amounting to a yearly average of $72.6 billion during 1980-1982 which had to be financed by foreign capital inflow. The corresponding deficits declined to an annual average of $10 billion in the following period of 1983-1990, and even in some years - at the height of current accounts deficits in the United States - there were net capital outflows from these countries. Under these conditions, investment programmes were scaled down in the developing countries, particularly programmes for the energy sector. And within that sector, the hardest hit were the programmes for the development and utilization of new and renewable sources of energy.

Table 10. Payment balances on current accounts, 1980-1990

(Billions of United States dollars)

	Developing countries		Developed countries		
	Fuel exporters	Others	United States	Japan	Federal Republic of Germany a/
1980	96.4	-65.7	1.9	-10.7	-13.8
1981	34.8	-83.3	6.9	4.8	-3.6
1982	-18.1	-68.8	-8.7	6.9	5.1
1983	-15.9	-28.1	-40.1	20.8	5.4
1984	-0.9	-9.2	-99.0	35.0	10.0
1985	1.8	-20.8	-122.3	49.2	16.5
1986	-33.0	-0.9	-145.4	85.8	39.5
1987	-8.1	20.5	-162.3	87.0	47.7
1988	-23.6	11.0	-128.9	79.6	50.3
1989	-6.4	-14.4	-110.0	57.2	55.3
1990	8.6	-37.6	-99.3	35.7	44.5

Source: International Monetary Fund, World Economic Outlook (Washington, D.C., 1988 and 1991).

a/ With effect from 3 October 1990, the Federal Republic of Germany and the German Democratic Republic united to form one sovereign State under the designation "Germany".

2. Methods and sources of financing

206. The financing of programmes and projects on new and renewable sources of energy in developing countries in the past has been carried out largely through external funding. In domestic financing, the government budget allocations have played the most important role, either directly or through banking and other credit systems; the participation of the private sector appears to have been rather limited. External financing has come from both bilateral and multilateral sources, and among the latter, intergovernmental organizations and the United Nations system, especially the World Bank Group and regional development banks, have provided the bulk of financing. In bilateral financing, the bulk has come through official development assistance (ODA) and some also from private sources.

207. There are no comprehensive up-to-date data available on total investment in the area of new and renewable sources of energy in developing countries. However, table 11, covering the period 1980-1986, provides a general view of funding sources for new and renewable sources of energy projects in developing countries. It shows that of the reported $35.9 billion that was funded for new and renewable sources of energy activities between 1980 and 1986, about 25 per cent came from domestic resources and the balance of 75 per cent from external sources. Of the latter, multilateral sources accounted for about 40 per cent, bilateral sources for nearly 20 per cent, private sources for around 7 per cent, and unspecified sources for the remaining 8 per cent. Hydropower accounted for about 75 per cent of the expenditures, followed by biomass, energy conservation, geothermal energy, energy planning, solar and wind energies, and others.

208. The United Nations system of organizations has provided substantial amounts of financing for new and renewable sources of energy projects in developing countries but, as indicated in table 12, the volume of such financing has declined in recent years, particularly if the contributions are calculated in real terms. Even in the case of the World Bank Group, which appears to have maintained the high level of its financing in nominal terms, the bulk of its commitment and contribution (about 70 per cent) went to hydropower projects, most of which had originated earlier.

209. Similarly, the UNDP financing commitments to new and renewable sources of energy projects were significant (about $310 million during the past decade) but declined from $37.3 million in 1983 to $20 million in 1990 - in real terms the decline being about 60 per cent. These commitments cover also the contributions of various funds managed by UNDP, including the Energy Account, the United Nations Sudano-Sahelian Office, the United Nations Capital Development Fund, the United Nations Special Industrial Services Programme, the United Nations Fund for Science and Technology for Development and the United Nations Development Fund for Women. In general, all of these funds have decreased sharply their funding of new and renewable sources of energy in recent years.

Table 11. Funding sources of new and renewable sources of energy activities in developing countries, during 1980-1986

(Millions of United States dollars)

	Domestic	Bilateral	Inter-governmental organizations	United Nations system	Private	Others	Total
Hydro	7 046	4 648	4 991	5 369	2 461	2 574	27 089
Geothermal	559	325	177	181	1	-	1 243
Solar	233	312	30	27	8	2	612
Wind	21	57	8	18	4	-	108
Biomass	494	569	246	1 003	3	47	2 362
Planning	124	228	234	542	2	23	1 153
Conservation	234	106	13	980	6	37	1 376
Others	550	423	235	686	11	57	1 962
Total	9 261	6 668	5 934	8 806	2 496	2 740	35 905

Source: "Promotion of the mobilization of the financial resources required in the implementation of the Nairobi Programme of Action" (A/AC.218/16), 1 February 1988.

210. The UNDP Energy Account, which had been conceived as an important channel of mobilizing additional resources for new and renewable sources of energy projects in developing countries, with the target of $100 million as its initial resource at the time of the Nairobi Conference, has faced a drastic decline in resource mobilization. During 1981-1990, its resource availability amounted to $40.4 million, of which 17 per cent came from voluntary contributions, 73 per cent from trust fund arrangements, and 10 per cent from interest and other income. Since 1988, voluntary contributions to the Account have ceased and its reduced activities are now being funded mainly through trust fund arrangements, which declined to $2 million to 1990. As a result, its project financing declined from $6.4 million in 1986 to $3 million in 1990.

Table 12. Financial commitments and contributions of United Nations organizations to new and renewable sources of energy in developing countries, 1980-1990

(Millions of United States dollars)

Year	UNDP		IBRD	IDA	Others	Total
	Total	Energy Account				
1980	12.8	..	833.2	529.1	6.0	1 386.1
1981	21.8	0.9	678.4	26.5	8.6	735.3
1982	30.7	1.9	758.0	457.4	14.1	1 260.2
1983	37.3	3.2	808.9	156.5	19.4	1 022.1
1984	34.8	3.6	1 198.9	252.2	17.8	1 503.7
1985	34.3	4.6	1 148.8	51.5	13.1	1 247.7
1986	28.2	6.4	1 281.9	238.2	10.8	1 559.1
1987	34.2	3.1	1 511.4	104.7	10.1	1 660.4
1988	28.9	4.8	1 009.3	64.8	5.3	1 108.3
1989	25.1	3.7	1 512.1	278.0	5.2	1 820.5
1990	20.0	3.0	1 586.2	143.9	3.6	1 753.7
Total	308.1	35.0	12 332.1	2 302.9	114.0	15 057.1

Source: United Nations Secretariat, Department of International Economic and Social Affairs.

211. There were high expectations that the Energy Account would mobilize substantial additional financial resources for the implementation of new and renewable sources of energy projects in developing countries and subsequently develop into an energy fund. At the suggestion of the Secretary-General, the Committee on New and Renewable Sources of Energy, recommended at its second session that the Governing Council of UNDP should review the interim arrangements for the Energy Account in order to ensure a more stable operation of the Account and to strengthen its activities to better enable it to respond to the needs of developing countries in the field of new and renewable sources of energy. At its third session (1986), the Committee endorsed the need to strengthen the Energy Account and invited the Governing Council to intensify its efforts to attract additional voluntary contributions so that the Account could expand its activities in responding to the needs of developing countries for the development and utilization of new and renewable sources of energy. However, in view of changes in the international energy scene and reduced interest in new and renewable sources of energy activities, the Governing Council of UNDP decided in July 1988 to close its Energy Office and transfer the Energy Account to the United Nations Fund for Science and Technology for Development, in the form of a separate subaccount.

212. Another mechanism envisaged by the Committee for mobilizing additional financial resources for the implementation of new and renewable sources of energy projects has been consultative meetings. They were conceived as a flexible way to bring together potential donors, recipients and interested organizations within and outside the United Nations system. In the past, a number of meetings were held at national, subregional, regional and global levels. But in recent years, in view of declining interest in new and renewable sources of energy activities, no such meetings have been organized. However, their effectiveness has not been conclusively ascertained.

213. A small fund, called the United Nations Trust Fund for the Development and Utilization of new and renewable sources of energy, was established in 1982 in the Office of the Director-General for Development and International Economic Cooperation. It was able to mobilize $2.5 million to finance a number of small projects.

214. The foregoing indicates that financing for new and renewable sources of energy programmes and projects, despite the successes achieved in the early part of the 1980s has generally declined in recent years. In the developed market economies, public expenditures for research, development and demonstration activities have been scaled down, and private involvement in new and renewable sources of energy investments has been greatly curtailed. In the developing world, with the exceptions of China and India, there have been similar trends, aggravated by the deterioration of domestic economic conditions in Africa and Latin America and the reduced availability of funding for new and renewable sources of energy activities from bilateral and multilateral sources, particularly in view of other needs and priorities.

215. However, quite recently there have been marked changes in perception of the global energy situation and its long-term prospects. Increasing concern about the environmental effects of expanded development and the use of conventional sources of energy has led to a revival of interest in energy transition, as recommended in the Nairobi Programme of Action. Undertaking remedial action to allay those concerns will require the renewal of efforts for mobilization of additional and adequate financial resources for new and renewable sources of energy programmes and projects all over the world, particularly in developing countries.

E. Commercialization and marketing factors

216. Strategies for the commercialization of new and renewable sources of energy technologies play a vital role in establishing and expanding markets for such technologies. In seeking to evolve appropriate strategies for commercialization, it is essential to establish an information base concerning current and future demand, along with national policies on industrial production and licensing, prospects for local production, availability of raw materials and components, marketing facilities, availability of skills, servicing requirements and infrastructure, a research and development base etc. The strategies will have to be comprehensive and able to support, in a sustainable manner, the full range of actions of the commercialization process.

217. Several new and renewable sources of energy technologies were expected to reach the stage of commercial readiness and become marketable in the 1980s. Anticipating large market potential for such technologies in developing countries, bilateral donors and multilateral agencies supported, through grants, commercial loans and credits, projects which involved a supply of new and renewable sources of energy devices and systems for demonstration and field testing. Entrepreneurs hastily looked for marketing opportunities without going through the adaptive process for technology transfer. Project activities turned out to be isolated. Many projects were unable to fulfil their objectives because of a rapidly changing technology and market environment. The commercialization effort received a set-back due to budgetary cutbacks in developed centres for demonstration and commercialization projects. Major oil companies which had involved themselves in new and renewable sources of energy and which had the necessary marketing abilities were unable to sustain their interest, due to a slump in oil prices. In the past 10 years, there has been a continuous reduction in the number of enterprises engaged in new and renewable sources of energy technologies. Few new investments have been made. The withdrawal of various tax rebates and concessions also had an adverse impact on the growth of new and renewable sources of energy industry.

218. The commercialization strategies followed by certain developing countries - notably, China and India - have focused on the diffusion of new and renewable sources of energy technologies based on the "extension" approach adopted widely in the agricultural sector. Both countries have adopted self-reliant approaches and developed technologies to suit their local conditions. In China, biogas plant development and application programmes were initially more or less State-driven, but lately commercial considerations are being increasingly applied. In India, national schemes have been introduced with varying levels of subsidy for biogas plants, improved wood stoves, solar cookers and water heaters. Other promising technologies are being introduced through national research, development and demonstration programmes in order to reach the "threshold" levels which are expected to generate demand and lead, eventually, to commercialization. Although the commercialization strategy in India is based on subsidies, those subsidies are expected to be withdrawn gradually.

219. The commercialization effort requires an institutional arrangement for financing projects. India has recently established a financing body exclusively for new and renewable sources of energy projects. Such actions in other countries will have a bearing on the mobilization of international cooperation.

220. The promotion of commercialization also requires innovative strategies. A programme begun in India a few years ago with USAID assistance exemplifies the kind of approach that could be adopted by other countries. The scheme, called Programme for Acceleration of Commercial Energy Research (PACER), promotes goal-oriented market-responsive technological innovation in the energy sector by means of financial assistance to a consortia of manufacturers, research institutions and end users from the public and private sectors. The consortia projects are backstopped wherever necessary by

competitive research awards and activities designed to analyse and disseminate information of relevance to technology development and commercialization. The programme is executed by the Industrial Credit and Investment Corporation of India under the overall guidance of the Department of Non-Governmental Sources of Energy in the Ministry of Energy, with a USAID grant of $20 million for a six-year period.

F. Techno-economic factors

221. Several new and renewable sources of energy technologies had reached the stage of "technical readiness" even before the Conference, and further developments and new applications were foreseen with the intensification of research and development in the 1980s and beyond. The initial high cost of new and renewable sources of energy technologies has been the main deterrent to wider utilization of those technologies. The economic viability of such technologies seemed attractive enough to be considered as potential oil substitutes, particularly at the time when the oil prices were relatively high. In the case of other new and renewable sources of energy technologies, which were not explicitly viewed as oil substitutes, the promotion was predicated on considerations of rural development, fuelwood supplies, environmental protection etc.

222. The economic viability of several new and renewable sources of energy technologies was hit by the drop in oil prices in 1986 and by the softer conditions that prevailed thereafter, except during the Gulf War. These factors, together with the slow down in economic growth of many countries, both developed and developing, adversely affected renewable energy development.

223. A recent World Bank study, based on data from 19 countries, indicates that most developing countries made only slight retail price adjustments in response to the 60 per cent drop in international oil prices between November 1985 and July 1986. In fact, few countries actually raised nominal retail prices periodically thereafter. The study also noted that although the drop in international product prices has been much more dramatic than that in retail prices, the financial viability of new and renewable sources of energy technologies has not been affected as much as their economic viability.

224. During the past decade, the costs of several new and renewable sources of energy technologies have fallen substantially. The economic sensitivity of renewable energy projects has been found to be primarily a function of their technology, scale and location. Some financing agencies do not give due consideration to features of new and renewable sources of energy such as short gestation time, larger employment potential, women's participation, environmental benefits, and improvement in health and sanitation in the rural areas of developing countries.

225. In the period just prior to the Conference on new and renewable sources of energy and soon thereafter, several large-scale projects were financed by national bodies and/or by assistance from multilateral agencies. They include the alcohol programme in Brazil, the dendero-thermal programme in the

Philippines, the use of bagasse for electricity generation in Africa, and large solar-thermal power plants and windfarms in the United States of America. Each of these projects has faced problems: in Brazil, the economic viability of the alcohol programme deteriorated due to the slump in oil prices; in the Philippines, the dendero-thermal programme was oversold and technical weaknesses remained unattended. On the other hand, solar power plants, windfarms and bagasse cogeneration projects have made significant headway due to technology improvements and innovative financing. Certain large projects failed to succeed because expected technology breakthroughs did not occur. Overall, the above problems and the drastic reduction in the funding of research, development and demonstration programmes were factors which adversely affected the implementation of the Nairobi Programme of Action.

G. Manufacturing capabilities and possibilities

226. The establishment and development of capacity at the national level for the manufacture, operation, maintenance, marketing and management of equipment and spare parts related to the use of new and renewable sources of energy were identified in the Nairobi Programme of Action as a priority area for action. International cooperation was expected to assist in facilitating the transfer and adaptation of technology which would enable manufacturing to be undertaken locally. In seeking to achieve these goals, developing countries face several obstacles and constraints. First, they face the uncertainties associated with the rapidly evolving nature of new and renewable sources of energy technologies and the broad range of choices - from solar thermal, electric and photovoltaic systems and wind electric systems to wood stoves, biogas plants, biomass gasifiers and so on. Secondly, they face the problem of having to adapt the technologies of interest to local conditions. They must also be prepared to provide: infrastructure, trained workers, testing and standardization facilities, and marketing and service capabilities.

227. The capability to manufacture new and renewable sources of energy equipment varies from country to country. But in the areas of service and maintenance, marketing and management of equipment for decentralized applications, major weaknesses exist. The less industrialized countries need assistance in order to enhance prospects for manufacturing.

228. The choice of technology and the scale of manufacturing are important considerations in ensuring successful manufacturing activities in developing countries. They need to have access to tools and techniques of technology assessment used in developed countries, not only to enhance their capability to enter into technology tie-ups but also make more informed judgements about joint ventures with respect to areas such as appropriateness of technology, research and development requirements for adaptation and improvement, unpackaging of technology, quality control and standardization to suit local conditions.

229. Only a few joint ventures have materialized, in spite of the vast scope that exists. For example, active and passive heating technologies, biomass-based technologies, and wind electricity generation are already widely

used in developed countries on a significant scale. Japan uses 5 million solar water heaters; in countries such as Australia, Israel, Italy and the United States the technology is well established. Similarly, photovoltaic technology, devices and systems hold great promise for joint ventures. In the actualization of these possibilities, many inhibiting factors need to be addressed such as non-availability of specialized raw materials, infrastructural bottlenecks, poor research and development back-up, poor marketing and service capability. Specific action for eliminating these factors must be taken. Many of them can be tackled by building capabilities within developing countries to undertake technical developments and their effective application. Cooperation will be needed for strengthening design and engineering capabilities, and establishing of appropriate institutions to promote manufacture, commercialization and application.

H. Socio-cultural factors

230. The Nairobi Programme of Action calls for actions that must take into account diverse socio-cultural situations. The issue concerns ways of creating awareness, of transferring technical and operational knowledge of new and renewable sources of energy technologies to people from different socio-cultural backgrounds, and of ensuring that the benefits reach the target groups. In seeking to assist countries in this respect, it is essential that attention be given to the following factors: tradition; social and economic disparities; race; religion; political structures, starting with the community level; values and beliefs; literacy of adults, youth, women and children; knowledge, attitudes and practices of health and sanitation; status of women; and acceptance of and compliance with new ideas and their adaptation. A lack of adequate attention to these factors could lead to the failure of an otherwise well conceived programme.

231. Decentralization of the planning and implementation process could enhance the prospects for the involvement of local people but might create resistance on the part of the government bodies, with control over funds to the local energy problems and to village-level initiatives. Some countries will need assistance to respond to local rural energy and rural development problems. The key issue is the integration of the energy requirements of rural populations into overall rural development, at the village level and at higher levels, with national energy plans and strategies. This calls for an intersectoral, interrelated, multilevel planning strategy, starting at the village-level and working up to larger clusters and thereafter to national planning bodies.

232. Deep-rooted problems of income disparity, poverty, landlessness, seasonal employment, subsistence agriculture, socio-political strictures of class and caste - all contribute to a social milieu which is not conducive to the creation of a market-responsive situation. Programmes, therefore, need to overcome these socio-cultural barriers to development and seek out new and imaginative approaches. New and renewable sources of energy applications which are linked to income-generation activities and employment will need to be accorded higher priority. Socio-culturally compatible technological

packages need to be developed and implemented, giving due attention to their acceptability, accessibility and affordability.

I. Environmental factors

233. The Nairobi Programme of Action stressed that increased use of new and renewable sources of energy should not cause harmful changes in the environment, but in so far as possible should, rather, improve environmental conditions. The current global focus on sustainable development and global warming issues provides a new, much needed impetus to renew and revitalize actions and measures to expand the environmentally beneficial uses of new and renewable sources of energy as far as possible. The key question is how to alter the energy mix, and at what economic and social cost, so that sustainable energy development and environment safeguards are assured. The future role of new and renewable sources of energy should emerge from such an inquiry.

234. The burning of fossil fuels and deforestation (fuel linked) lead to the release of carbon dioxide into the atmosphere. Together, the OECD countries, Eastern Europe and the Soviet Union are responsible for 54 per cent of all greenhouse gas emissions. Certain combustion pressures are also responsible for acidification caused by SO_2 and oxides of nitrogen.

235. The Nairobi Programme of Action considers the fuelwood problem one requiring priority action. The problem has become urgent in view of increasing land degradation, including deforestation and desertification. It needs to be tackled through a holistic approach leading to sustainable land management.

236. It is estimated that carbon dioxide will double in the atmosphere if current energy trends continue. Such a CO_2 doubling could result in warming of 1.5-3° Centigrade, by the second half of the twenty-first century.

237. Nuclear energy presents risks in terms of waste disposal and the proliferation of nuclear weapons.

J. Rural energy supplies

238. For a number of reasons, new and renewable sources of energy have failed to meet their promise in rural areas. First, many of these technologies had not yet become economically competitive with alternative energy sources. Secondly, there has been a lack of policy support in many instances arising from general neglect of the rural sector, which has contributed to the paucity of investment in projects to develop new and renewable sources of energy in rural areas. Thirdly, a number of technologies have not been readily accepted because their introduction has not taken fully into account socio-cultural factors. Lastly, rural poverty, which has largely ruled out commercial energy sources, might make it difficult to undertake even very modest investments in new and renewable energy, especially in the absence of government interest.

239. The scarcity of information on the rural energy sector and the difficulty of obtaining it constitute important constraints in the selection and diffusion of appropriate technological options. Much of the available information is geared to the needs of decision makers and not to personnel in the field. Past attempts to collect data on rural energy have often been static in nature and content: the data collected provided a snapshot of the energy situation but were not able to capture the dynamic and fluid nature of rural energy. Part of the problem is that those active in the field belong to many different disciplines and do not publish or otherwise make available information on their work.

240. Past attempts at addressing the rural energy question tended to focus on specific technologies for generating energy - for example, a microhydro plant or a biogas plant. As a result, current understanding of how stand-alone energy technologies perform is not matched by an adequate appreciation of the institutional environment that is necessary for the successful introduction of rural energy technologies.

241. It is necessary to address basic needs in rural areas. In particular, special effort should be directed towards enhancing equity in these areas. The introduction of rural energy technologies is not in itself sufficient to address the question of equity. In certain cases, rural energy technologies may widen income gaps instead of narrowing them.

242. A major problem continues to be the urban bias of both national and outside investment sources. This issue is related to political development efforts in the rural areas of developing countries, which, with a few exceptions, have not yet led to equitable distribution of income and economic development efforts in those areas. In many cases, conventional energy sources in developed and developing countries have been subsidized for long periods of time. The expansion of rural energy supplies would also require subsidies, especially with regard to new energy technologies. However, as an overall policy, end users would eventually have to finance investments through competitive prices. In some cases, a nominal price, at least, would have to be charged as an incentive to users to maintain energy facilities properly.

V. CONCLUSIONS AND RECOMMENDATIONS

A. Conclusions

243. The adoption of the Nairobi Programme of Action was considered the cornerstone of transition to a new energy system. In the Nairobi Programme of Action, the international community proclaimed its commitment to an orderly and peaceful energy transition, from an international economy based primarily on hydrocarbons to one based increasingly on new and renewable sources of energy, in a manner which was consistent with the needs and options of individual countries, and socially equitable, economically and technically viable and environmentally sustainable.

244. The United Nations Conference on New and Renewable Sources of Energy took place at the height of the second international energy crisis and in the midst of great uncertainties as regards the security and adequacy of the future supply of hydrocarbons and their prices. There were hopes and expectations that the world's future energy conditions would be improved with the implementation of the Nairobi Programme of Action. International cooperation was called for to assist developing countries in their efforts to promote the development and utilization of new and renewable sources of energy. Efforts were made nearly everywhere, with different degrees of intensity. Success was achieved in a number of countries and in certain technologies, showing the viability and practicability of the development and use of new and renewable sources of energy.

245. These activities continued to move from the stage of research to that of development, in industrial and developing countries alike, until the mid-1980s, when energy prices, particularly oil prices, fell sharply. They have since stabilized at a much lower level. This, together with renewed strength in the world economy, has resulted in a reversal of the immediate past trends and a resumption of growth in energy demand in the developed market economies and an acceleration in the rate of increase of energy consumption in the developing world. Energy investments have been cut substantially on a world-wide basis. Interest in new and renewable sources of energy has waned, with major cutbacks in public and private sector funding at the national level and in multilateral and bilateral assistance programmes. Many new and renewable sources of energy programmes and projects have been abandoned and others scaled down in the developing countries.

246. The past few years have witnessed a revival of strong interest in new and renewable sources of energy development, with the aim of contributing significantly to the growing global energy requirements. Increasing concern is being expressed in many quarters all over the world about the harmful environmental effects of excessive use of most conventional energy sources. This is in addition to the growing apprehension concerning the re-emergence of uncertainties over the future supply and prices of fossil fuels. Hence, the attention of the international community is again drawn to the necessity of expediting the development and utilization of non-pollutant and sustainable systems, particularly new and renewable sources of energy.

247. Although new and renewable sources of energy vary in technological development and availability from one country to another, they have certain common characteristics: wide geographical dispersion; independence from finite resources; low power density and, for many, periodicity of supply; availability in small sizes which are installed quickly; high capital cost but low operating expenses; intensive worker requirements; and relatively low environmental impact.

248. The world is thus currently facing a double urgency for the development and use of new and renewable sources of energy: first, because of the rapid environmental deterioration resulting from the use of fossil fuels; and secondly, because of the need for increasing energy self-reliance, particularly in the light of experiences of the past two decades and the possibilities of future uncertainties. In addition, it is realized that in the coming decades, a growing share of global incremental energy demand will originate in developing countries, and the economic and financial burden of energy imports in most of the energy-importing countries will undoubtedly be far beyond their capacity, greatly impeding their growth, with unfavourable consequences to the world economy. The present global energy situation, therefore, appears to call for a strong and serious commitment, by the international community, to achieving the objectives of the Nairobi Programme of Action.

249. The action areas include the building of the necessary new and renewable sources of energy infrastructure; formulation of governmental policies and incentives; assessment of new and renewable sources of energy resources; preparation of new and renewable sources of energy programmes and projects; mobilization of financial resources; undertaking research and development activities; construction of demonstration projects; promotion of new and renewable sources of energy technologies; collection and dissemination of information; training of professionals and technicians; development of manufacturing facilities; diffusion of new energy systems; and commercialization of proven technologies. Greater attention should be given to the development of those technologies which are most promising and economically viable, consistent with each country's resource availability and national energy policy. This would involve such sources as solar, wind, biomass, fuelwood and charcoal, hydropower and geothermal energies.

250. The role and the importance of new and renewable sources of energy, in the development process of all countries - in particular, developing countries - and in the evolution of a better energy mix, taking into account relevant issues, problems, and constraints, need to be refocused more strongly than before.

251. Although significant progress has been achieved in the developed countries on energy conservation, further increases in energy consumption in the developing countries are inescapable, judging from trends in energy intensities in those countries. Energy conservation programmes should be formulated and implemented in developing countries, as an integral part of energy development policies and plans.

252. The world-wide contribution of new and renewable sources of energy, including traditional sources, currently stands at more than 14 per cent of total energy supplies. In the developing countries, the contribution of new and renewable sources of energy is, however, many times higher, particularly in Africa, where more than 60 per cent of energy requirements are met by these sources.

253. There is a clear need for intensified national efforts and for strengthened international cooperation, in order to develop and apply new and renewable sources of energy technologies, in the developing countries. While numerous activities have been undertaken in the implementation of the Nairobi Programme of Action, both at the national and international levels, further concerted effort is needed if the present and future energy needs of the vast majority of the poor in the developing countries are to be met.

254. In the rural areas of many developing countries, there has been increasing pressure on traditional sources of energy - in particular, fuelwood - as a result of rapid population growth, coupled with unavailability of affordable alternative energy sources. In some countries, the consequent deforestation and denuding of the countryside has created a crisis of major magnitude with far-reaching social, economic, and environmental consequences. The search for a solution to this problem, as part of overall rural energy supply and the broader issue of rural development, deserves high priority.

B. Recommendations

255. The main thrust of the Nairobi Programme of Action and its overall recommendations continue to be valid. However, an overall review of its priorities may be required, especially in light of changes that have taken place in the past decade in such areas as energy, ecology, finance, economic growth, and the state of development and application of new and renewable sources of energy technologies. The priority areas would differ among countries, depending on the nature of their available energy sources, progress in actions taken in specific policy areas, and development and feasibility of application of various technologies.

256. There is a need to secure policy commitments from all countries and the international community for concerted action for the realization of the objectives of the Nairobi Programme of Action. There is need for political will at the highest levels in each country and for such a will to be translated into specifications for further development and use of new and renewable sources of energy. The rules of the present energy economy favour the rapid expansion of fossil fuels. Therefore, the transition to a sustainable energy economy requires a major shift in policies and priorities in favour of new and renewable sources of energy. New energy policies should respond to the increasing concern of the international community on the negative environmental impact of existing energy systems.

257. At the national level, the development of new and renewable sources of energy should be considered in the context of the overall development plans and priorities of each country and coordinated as an integral part of energy sector programmes. Energy policies should provide reasonable and adequate incentives for the development and use of new and renewable sources of energy and should eliminate or reduce price distortions in favour of conventional energy sources. In addition, policies will have to be adopted to ensure, inter alia, the establishment or strengthening of necessary institutions for policy implementation, promotion and application of appropriate technologies, the training of personnel and the mobilization of financial resources. Moreover, they should be able to interact with other development sectors, particularly with regard to rural development, women's welfare, agriculture etc. Successful experiences in Brazil, China, Egypt and India should provide useful guides.

258. Steps should be taken to develop institutions for new and renewable sources of energy at the state/provincial levels, with linkages to the central level. National plans for new and renewable sources of energy should be made in the five-year annual plans for research, development and demonstration and for supporting applications to ensure sustained efforts and enable targets and goals to be fixed and monitored. This would generate interest and confidence in bilateral and financial support. Effort should be directed more towards project planning and implementation. The projects undertaken should not be too small or subcritical; they should link with national priorities and should produce a perceptible impact and benefit to people.

259. Currently, the Economic and Social Council is examining all institutional arrangements under its purview, including those on overall energy and new and renewable sources of energy. In the light of the decisions of the Economic and Social Council, consideration will be given to secretariat arrangements.

260. In line with the recommendations of the Castel Gondolfo Colloquium of High-level Experts on New and Renewable Sources of Energy, there is need for identification and strengthening of new and renewable sources of energy institutions with a view to making them centres of excellence of international scope for new and renewable sources of energy technologies, and for the establishment of regional new and renewable sources of energy centres and networks. The findings of the Consultative Group on the feasibility of establishing such centres should be reviewed and implemented, as appropriate.

261. It would also be necessary to create awareness through various media by such activities as:

(a) Organizing and supporting exhibitions, shows and seminars;

(b) Publicizing various efforts through audiovisual means, posters, pamphlets, handouts and video cassettes;

(c) Press releases and public information material;

(d) Mobile exhibitions to be taken to rural areas;

(e) Public information centres;

(f) Involvement of mass communication professionals;

(g) International networks;

(h) Extension services.

262. The reinvigoration of the Nairobi Programme of Action and its effective implementation, in line with new priorities during the next decade, will require additional adequate financial resources. In view of the shortfalls in resource mobilization for new and renewable sources of energy activities and its declining trend in recent years, new political will and concerted efforts are needed by the international community, if it is agreed that the energy transition to new and renewable sources of energy and energy self-reliance is a priority area for international cooperation. Greater efforts will have to be made by developing countries, to the extent possible, for mobilizing domestic resources to finance an increasing share of new and renewable sources of energy expenditures, particularly in view of the grim prospects of possibilities for external financing. But in most of the low-income and least developed countries, with relatively little income to save, such efforts may achieve only meagre results. Therefore, domestic resources will need to be supplemented by inputs from multilateral, bilateral and private sources.

263. However, it is important that predictable and adequate budgetary allocations be made through the national development plans for new and renewable sources of energy activities in order to ensure sustained efforts for successful realization of the established targets and goals. Consideration may be given to the mobilization of additional domestic financial resources through, inter alia, new energy taxes, particularly on imported fuels, which could be devoted to the development of indigenous energy sources, including new and renewable sources of energy, particularly, in rural areas.

264. Increasing assistance would also be needed by developing countries from the international community in the implementation of their energy programmes. In view of substantial financial requirements for supporting actions and pre-investment activities, there is need for a significant grant element in financing such operations. Moreover, with respect to other financial requirements and taking into account the nature of new and renewable sources of energy projects, there is need for considering flexibility in repayment terms in order to make adjustment to particular conditions and developmental needs of individual countries, especially the least developed.

265. Bilateral cooperation (and especially official development assistance) is likely to continue to be one of the major channels of resource transfer to new and renewable sources of energy activities in developing countries. In view of growing environmental concerns about the use of conventional sources of

energy and apprehension about the future supply and prices of fossil fuels, developed countries may consider giving higher priority to new and renewable sources of energy development and utilization and supporting effectively international cooperation in this area. Developing countries in a position to provide assistance to other developing countries would also be expected to reconsider their position and restore their assistance to the energy sector of other developing countries, especially to new and renewable sources of energy activities.

266. Multilateral financial institutions, including the World Bank group, the regional development banks and UNDP, continue to provide substantial external funding and/or technical assistance for development projects in developing countries. At the same time they play a very important catalytic role in attracting additional resources from other foreign sources. However, as noted above, the contributions of these institutions to the development in developing countries of new and renewable sources of energy other than hydropower and fuelwood have been reduced in recent years. They are in a position to play a leading role in assisting the developing countries in the development of primary sources of energy, especially new and renewable sources of energy, provided priority is given by their governing bodies to such activities.

267. In view of changes in the global energy situation and environmental concerns, UNDP may be requested to consider the revival of its fading Energy Account and converting it to an energy fund, as originally conceived. The fund, if strengthened institutionally and provided with additional and adequate resources, would be able to extend wide-ranging technical assistance support to developing countries in their new and renewable sources of energy plans and programmes.

268. At the same time, efforts should be made by the Secretariat for the reactivation of consultative meetings at the national, regional and global levels. If properly conceived and organized, they could be an effective and flexible mechanism for promoting cooperation among donors, recipients and interested organizations within and outside the United Nations system for mobilization of additional financial resources for implementation of new and renewable sources of energy projects in developing countries.

269. Greater consideration may also be given to financing possibilities under third-party cost-sharing projects and funds-in-trust arrangements. Vigorous and innovative efforts are also required for attracting private capital. For promotion of private investment in new and renewable sources of energy, the Multilateral Investment Guarantee Agency (MIGA) at the World Bank plays a useful role.

270. Note should also be made of the current initiatives and actions in relation to the global environmental facility within the World Bank (in cooperation with the United Nations Development Programme and the United Nations Environment Programme). The facility should be able to fund projects in new and renewable sources of energy. To this end special efforts should be

made to encourage countries to take advantage of the facility by helping interested countries to formulate suitable projects.

271. Developing countries should also be assisted in strengthening or establishing capacities for manufacturing new and renewable sources of energy equipment and in the evolution of their maintenance and management services. Manufacturing industries should be promoted in appropriate developing countries to ensure increased utilization of new and renewable sources of energy and, in the process, to develop local know-how and capability for acquiring and adapting technologies to suit local conditions. To this end relevant manufacturing standards and specifications should be developed. At the same time, joint ventures should be promoted.

272. Socio-cultural and political aspects of energy development and use - in particular new and renewable sources of energy - should receive closer analysis. Full participation of intended users in the planning, design and implementation of projects should be part of project development in order to ensure acceptance of the new knowledge or systems. In the rural areas of the developing countries the role of women with reference to energy, including new and renewable sources of energy, and integrated rural development requires closer attention.

273. Developing countries may also require assistance in the development of credit and marketing systems designed to promote the development and use of promising new and renewable sources of energy technologies.

274. New and renewable sources of energy should be incorporated into investment and pricing policies and schemes for all energy sources. Full account should be taken of all costs, external and internal, and of environmental and social impacts.

275. In the light of the growing interest in new and renewable sources of energy in relation to the environment, assessment should be made of the environmental impact of new and renewable sources of energy as compared to conventional sources. Such an assessment should include rural, national and global effects with projects, incorporating scenarios and expanded use and development of new and renewable sources of energy. Associated with this, an evaluation should be made of the environmental impact of energy, including new and renewable sources of energy, in rural areas, taking note of the competition and conflict between alternative uses of land and competing uses of biomass.

Notes

1/ See Official Records of the General Assembly, Forty-fifth Session, Supplement No. 36 (A/45/36), annex, resolution 2 (V).

2/ Report of the United Nations Conference on New and Renewable Sources of Energy, Nairobi, 10-21 August 1981 (United Nations publication, Sales No. E.81.I.24), chap. I, sect. A.

3/ Implementation of resolution 2 (III) of the Committee on the Development and Utilization of New and Renewable Sources of Energy at its third session (A/AC.218/15).

4/ "Financial requirements for supporting actions and pre-investment activities for new and renewable sources of energy in developing countries during the 1980s", a joint study prepared by the World Bank and the United Nations Development Programme (A/AC.215/4), April 1982.